INSTRUCTION MANUAL

MEMO-SCOPE OSCILLOSCOPE

MODEL 104-D

INDUSTRIAL SYSTEMS DIVISION

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

HUGHES AIRCRAFT COMPANY

International Airport Station, Los Angeles 45, California U.S.A.

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SWEEP TRIGGER CONTROL IMPROVEMENT

A dual TRIG LEVEL control has been incorporated in model 104-D MEMO-SCOPE® Oscilloscopes after serial number 320.

The large black knob controls the level at which the sweep will be triggered and the small red knob is for trigger stability.

SWEEP TRIGGERING SUGGESTIONS

The MEMO-SCOPE Oscilloscope may be set to trigger from an applied repetitive signal in the following manner:

For positive signals:

a. Set the TRIG SEL switch to a positive (+) setting in the mode desired, e.g. INT AC +, EXT DC +, etc. Turn TRIG LEVEL controls full clockwise—both black and red knobs. Observe that the SWEEP READY indicator is lighted.

b. Slowly rotate the black TRIG LEVEL knob counter-clockwise until a trace is observed on the MEMOTRON® tube screen. Note that the SWEEP READY indicator has decreased in intensity or extinguished.

c. Adjust the red TRIG LEVEL control to eliminate jitter, double traces, and flyback tails at the right side of the screen.

For negative signals:

a. Set the TRIG SEL switch to a negative (−) setting in the mode desired, e.g. INT AC −, EXT DC −, etc. Turn the black TRIG LEVEL control full counter-clockwise and the red control full clockwise. Observe that the SWEEP READY indicator is lighted.

b. Slowly rotate the black TRIG LEVEL control clockwise until a trace is observed on the MEMOTRON tube screen. Note that the SWEEP READY indicator has decreased in intensity or extinguished.

c. Adjust the red TRIG LEVEL control to eliminate jitter, double traces, and flyback tails at the right side of the screen.

The MEMO-SCOPE Oscilloscope may be set to trigger from unknown signals in the following manner:

For positive signals:

a. Set the TRIG SEL switch to a positive (+) setting in the mode desired, e.g. INT AC +, EXT DC +, etc. Turn TRIG LEVEL controls full clockwise—both black and red knobs. Observe that the SWEEP READY indicator is lighted.

b. Slowly rotate the black TRIG LEVEL control counter-clockwise until the SWEEP READY indicator reduces intensity or extinguishes, then slowly clockwise until the SWEEP READY indicator ignites to full brilliance. The trigger sensitivity is now approximately maximum for a positive-going trigger signal.

For negative signals:

a. Set the TRIG SEL switch to a negative (−) setting in the mode desired, e.g. INT AC −, EXT DC −, etc. Turn the black TRIG LEVEL control full counter-clockwise and the red TRIG LEVEL control full clockwise. Observe that the SWEEP READY indicator is lighted.

b. Slowly rotate the black TRIG LEVEL control clockwise until the SWEEP READY indicator reduces intensity or extinguishes, then slowly counter-clockwise until the SWEEP READY indicator ignites to full brilliance. The trigger sensitivity is now approximately maximum for a negative-going trigger signal.

WARNING

KEEP THE MEMO-SCOPE OSCILLOSCOPE LEVEL or with the CONTROL PANEL TILTED UP. This is to prevent any small particles which may be inside the MEMOTRON® tube storage tube from falling or collecting on the delicate elements of the tube.

KEEP INTENSITY OF WRITING BEAM AS LOW AS POSSIBLE (minimum intensity consistent with beam writing speed). This precaution is necessary to avoid damage to the storage mesh of the MEMOTRON tube.

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Figure 1. Front Panel, MEMO-SCOPE Oscilloscope, Model 104-D, with WB/4 Preamplifier, Optional Camera Mount, and Speed Enhancement Circuit

SECTION I
INTRODUCTION AND DESCRIPTION

1-1. INTRODUCTION.

1-2. The Model 104-D MEMO-SCOPE oscilloscope is a storage type oscilloscope. In addition to its capabilities for use as a conventional type oscilloscope, the MEMO-SCOPE oscilloscope has the feature of being able to retain the displayed traces of waveforms, and retaining such traces on the screen for as long as desired (within limits stated in Section II, OPERATING INSTRUCTIONS).

Thus, non-periodic waveforms, transients, and spurious signals of a "one-shot" nature can be displayed, and then retained on the screen of the CRT after they have gone. When using this feature, the stored display on the MEMO-SCOPE oscilloscope is much like that of a photograph, holding for later study information which would ordinarily be difficult or impossible to visually observe during its actual occurence.

1-3. MEMOTRON TUBE. To accomplish its storage feature, the MEMO-SCOPE oscilloscope uses a Hughes Products MEMOTRON tube (RETMA 6498). This unusual tube stores the trace of the writing beam (the electron beam), and displays this trace with whatever brightness is required, at a constant intensity. The trace can be stored indefinitely, with appropriate voltages applied through selective positioning of the storage controls on the front panel of the MEMO-SCOPE oscilloscope.

The MEMOTRON tube thus acts as a CRT with a controllable persistence: (1) For normal operation as a conventional oscilloscope, a short persistence may be selected (storage control off); (2) For storage operation, proper positioning of the storage controls converts the MEMOTRON tube to a long persistence tube.

When using the storage feature, the stored trace can be retained for as long as desired, and then erased by simply depressing the ERASE button on the front panel of the MEMO-SCOPE oscilloscope (see figure 1), or by grounding the external ERASE jack.

1-4. THE STORAGE MECHANISM. The MEMOTRON tube has a dielectric storage mesh and two electron guns: (1) Writing Gun; (2) Flood Gun.

The flood gun (figure 2) sprays the dielectric storage surface with a uniform barrage of low-velocity electrons. The dielectric surface is assumed to be initially at zero potential (flood gun cathode potential). The high-velocity electron beam from the writing gun charges regions of the storage surface positive as a result of secondary emission, thus creating areas which are partially transparent to the flood electrons. Those which pass through the positively charged areas are accelerated to high velocity, and strike the viewing screen phosphor, producing a continuously visible image of the pattern electrically stored on the dielectric surface.

In addition to providing the electrons necessary for displaying the written information, the flood gun beam also maintains the positive and negative potentials of the charged pattern on the storage surface. This pattern may be erased by momentarily lowering the voltage on the secondary collector mesh inserted between the writing gun and the dielectric surface. A given area on the storage mesh may be at one of two stable conditions, either at collector or at flood gun cathode potential. All written information will be displayed at full brilliance with no presentation of half-tone information.

1-5. Operation Without Storage: The MEMO-SCOPE oscilloscope can be used with the storage controls turned counterclockwise and FLOOD GUN turned OFF, causing it to operate exactly like a conventional oscilloscope. This mode of operation (in addition to its obvious use) is very useful in preliminary adjustments to establish the proper sweep and amplitude adjustments for later observation of transient phenomena in the storage mode.

1-6. Beam Intensity: As in any conventional oscilloscope, the writing gun intensity must be increased when faster writing speeds are used. Insufficient beam intensity will result in partial storage of the trace. Similarly, too high an intensity for the writing speed being used will cause "blooming" of the trace, and fogging of the background, especially at very low writing speeds.

WARNING

When writing at frequencies of 20 cps and lower, or at trace speeds of less than 100 inches per second, be careful to use only the beam intensity that will just store the trace. Writing with greater intensity may result in permanent damage to the storage surface (refer to paragraph 2-12).

1-7. Blanking: The writing beam must not only be blanked while the sweep is returning from right to

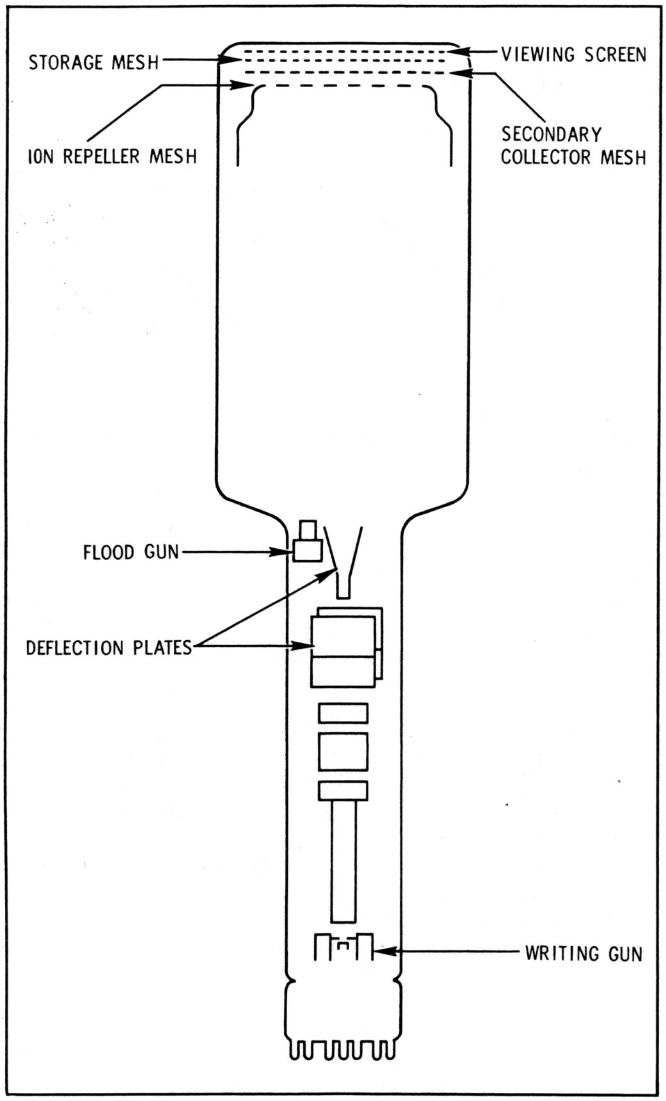


Figure 2. MEMOTRON Tube, Simplified Crossection

left, but must also be held off until the beginning of the sweep. If the beam is left on in one place on the tube face, the spot will gradually build up in time from the stray electrons, and a general increase in background will result. The blanking circuits of the MEMO-SCOPE oscilloscope are designed to turn the writing beam on only during the left-to-right travel of the sweep. The beam is held off at all other times. When using external sweeps, the EXT BLANK connection may be used for controlling the beam in a similar manner.

1-8. Erasing: The stored trace is erased by depressing the ERASE button or by momentarily grounding the external ERASE connection on the front panel of the MEMO-SCOPE oscilloscope.

1-9. FUNCTION OF CONTROLS FOR MEMO-SCOPE OSCILLOSCOPE. For the location of the controls discussed in the following paragraphs, see figure 1 (front panel of MEMO-SCOPE oscilloscope). The control names used in the following paragraphs are exactly as they appear on the MEMO-SCOPE oscilloscope, and are capitalized: TRIG LEVEL, EXT TRIG, etc., as marked on the front panel. The block diagram shown in figure 3 illustrates in a simple schematic manner the relationship of these controls and connectors to their related circuits in the MEMO-SCOPE oscilloscope.

1-10. Sweep Circuit Controls:

TRIG LEVEL -- Adjusts the level of the trigger waveform at which the sweep will trigger. Range, approximately ±10 volts for the EXT TRIG X1 input.

TRIG SEL -- Selects the desired triggering waveform for the sweep generator. The waveform may be obtained from the vertical amplifier (INT), from the power line (LINE), or from an external signal applied to the EXT TRIG connector (EXT). The sweep may be caused to trigger off the negative or positive slope (+ and -) of the trigger signal with a signal level of at least one division. The sweep may be triggered internally using the INT AC connection if the signals are above a frequency of approximately 50 cps. For frequencies below this level, use the INT DC connection, which may be used down to a frequency of less than 10 cps. Signals below this level, and down to DC, may be triggered externally at the EXT TRIG connector with the TRIG SEL in the EXT DC position.

EXT TRIG X1, ÷10 -- This switch attenuates the EXT TRIG signal by a factor of approximately 10 times. In the X1 position, the TRIG LEVEL adjusts the triggering over approximately ±10 volts. The ÷10 position allows adjustment over approximately ±100 volts.

TIME/DIV -- Selects the sweep speeds in decade steps, and indicates the sweep speed directly in time per division of the graduated reticle (1/3-inch squares) over the MEMOTRON tube face. Also switches the horizontal amplifier input to the EXT SWEEP connector, either directly (X1) or through a 10:1 attenuator (X10). When in the sweep positions, the sweep multiplier is selected by the SWEEP MULT control. When in EXT SWEEP position, the horizontal amplifier gain is varied continuously over a 10:1 range by the sweep vernier 10:1 control.

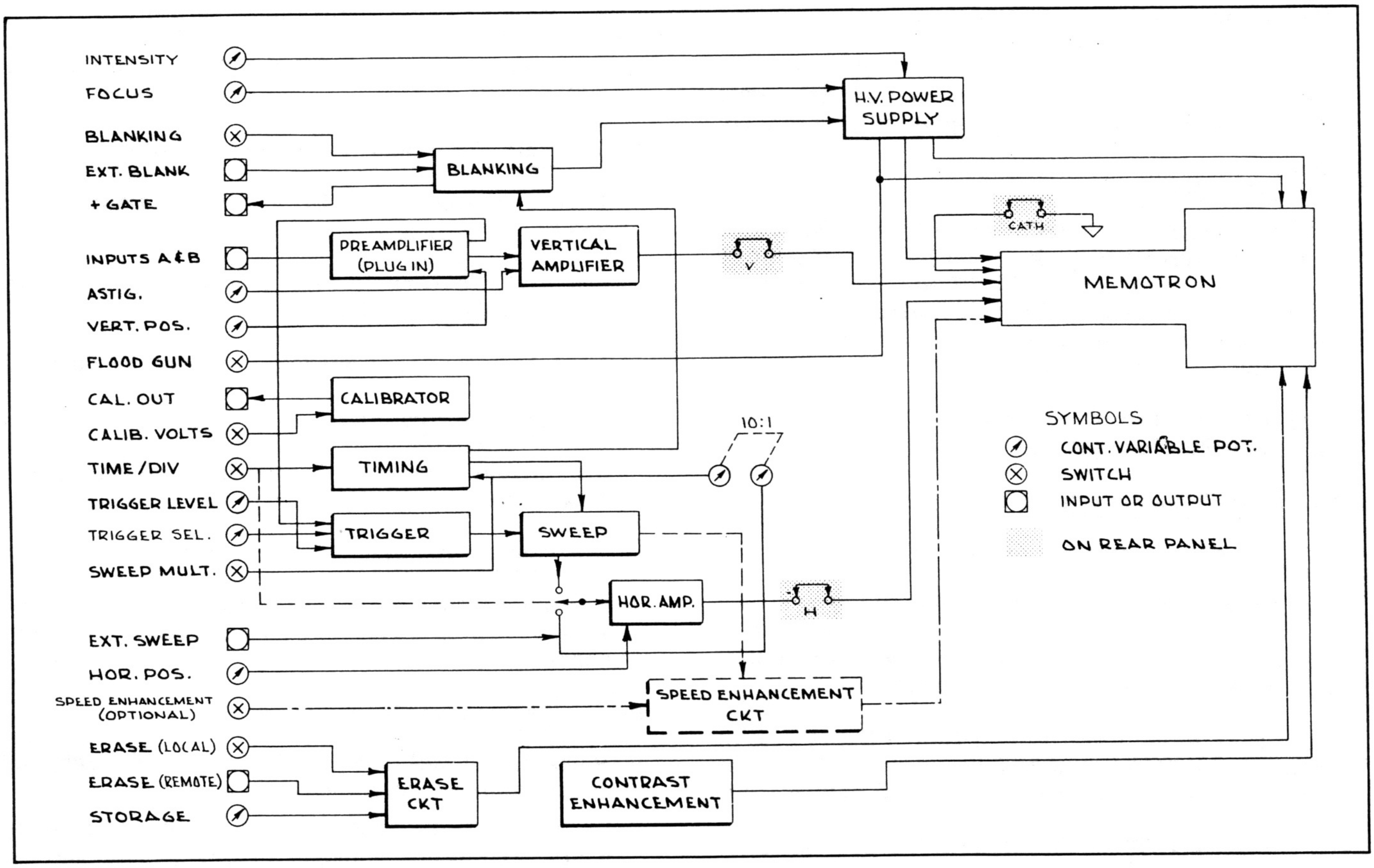


Figure 3. Block Diagram, Model 104-D

SWEEP MULT -- Provides calibrated multipliers of X1, X2, and X5 which multiply the TIME/DIV readings to indicate the actual sweep speed in seconds per division. Also selects the sweep vernier 10:1 control for continuous variation of the sweep speed over a 10-to-1 range.

EXT SWEEP connection -- Input for the EXT SWEEP waveform. Selected by TIME/DIV control.

EXT TRIG connection -- Input for EXT TRIG (external trigger) waveform. Selected by TRIG SEL, attenuated by EXT TRIG switch.

+ GATE connection -- When the trace is being displayed, the voltage at the + GATE connection is 0 volts. During flyback and waiting time, the voltage is approximately -20 volts.

SWEEP READY lamp -- Indicates, when illuminated, that the sweep is ready to receive a trigger.

BLANKING ON -- When BLANKING ON switch is on (up), the trace is blanked from an internal signal during retrace period and while waiting for the next sweep trigger. When in the on (up) position, the trace may be blanked externally by a -20 volt signal applied at the EXT BLANK connector (TIME/DIV switch in the EXT SWEEP position), and on blanked by raising the external signal to about 0 volt.

When BLANKING ON switch is off (down), there is no blanking of the trace.

EXT BLANK connection -- Input for external blanking signal. Connected to blanking circuit when TIME/DIV is in any sweep position.

1-11. Storage Controls:

FLOOD GUN switch -- Selects MEMOTRON tube flood gun ON or OFF.

STORAGE -- Adjusts collector mesh potential to provide optimum storage conditions.

ERASE push button -- Provides manual means for erasing the stored display.

ERASE connector -- By momentarily grounding this connector, the stored display will be erased.

1-12. Calibrator:

CALIB VOLTS -- Selects one of four calibrated square waves with peak-to-peak amplitudes of 10 volts, 1 volt, 0.1 volt, and 0.01 volt. Square wave is based on ground, and goes positive. Frequency of the calibration square wave is approximately 1 kc. Amplitude accuracy: ±3%.

CAL OUT -- Calibrator voltages appear between this connector and ground.

1-13. Miscellaneous Controls:

INT -- Adjusts intensity of writing beam.

FOCUS -- Adjusts focusing of writing beam.

ASTIG -- Corrects for astigmatism distortion. Optimizes dot size over CRT screen.

SCALE -- Adjusts the illumination of the reticle in front of the MEMOTRON tube screen. Complete counterclockwise rotation turns off illumination.

1-14. MEMO-SCOPE OSCILLOSCOPE, MODEL 104-D, SPECIFICATIONS.

1-15. Storage Tube:

Maximum writing speed for storage: 125,000 inches/sec. (without speed enhancement -- see Section V).

Storage Potential: Continuously adjustable to provide optimum storage.

Accelerating Potential: Writing gun, 3000 volts; flood gun, 200 volts; viewing screen, 5000 volts (maximum).

Deflection Plates: Available at rear terminal strip for direct connection. Direct to deflection plates: 90 to 100 volts/inch.

1-16. Main Vertical Deflection Amplifier:

Frequency Response: DC to 500 kc; down 3 db at 500 kc.

1-17. Main Horizontal Deflection Amplifier:

Frequency Response: DC to 250 kc. Down 3 db at 250 kc.

Sensitivity (external): 0.5 to 50 volts per division, continuously variable.

Input Impedance: 1 megohm shunted by 50 mmf.

1-18. Illuminated Reticle:

Illuminated scale calibrated in a 3-inch square, 10 x 10 array.

1-19. Power Supply:

Requirements: 105 to 130 volts, 50/60 cycles, 250 watts. All DC voltages regulated against line changes.

1-20. Mechanical Construction:

Portable (Model 104-D): 13" wide, 14" high, 20" deep; shipping weight approx. 66 lbs.

Rack Mounted (Model 104-D (Rack)): 14" panel width, 21" deep; shipping weight approx. 90 lbs.

1-21. ACCESSORY EQUIPMENT. Optional accessory equipment to increase the efficiency and utility of the Model 104-D MEMO-SCOPE oscilloscope is available from Hughes Products as follows:

1. WB/4-D Preamplifier (shown installed in MEMO-SCOPE oscilloscope in figure 1).
2. HS/6 (or HS/6-D) High Sensitivity Preamplifier
3. WB/DI/11 (or WB/DI/11) Dual Trace Preamplifier
4. Camera Mount, HAC E-000146
5. Writing Speed Enhancement Circuit (available only at time of original purchase)

Complete information on the use of these accessories, as well as complete circuit descriptions, operating instructions, and maintenance data are provided in Section V of this instruction manual.

SECTION II
OPERATING INSTRUCTIONS

2-1. TURN-ON INSTRUCTIONS.

2-2. When turning the MEMO-SCOPE oscilloscope ON for the first time, it is recommended that the following procedure be used.

NOTE

The following procedures apply when using any of the preamplifiers listed in Section V.

2-3. Initial Turn-On: First, before any external connections are made, adjust all controls on the front panel of the MEMO-SCOPE oscilloscope as follows:

TRIG LEVEL	O (centered)
INT	All the way counterclockwise
TRIG SEL	Line +
SCALE	Any position
ASTIG	Approximately centered
FOCUS	Approximately centered
V POS	Approximately centered
H POS	Approximately centered
STORAGE	All the way counterclockwise
FLOOD GUN	OFF
BLANKING ON	OFF (down)
POWER ON	OFF

2-4. Turn-On Without Storage: Connect the preamplifier input to a 6-volt 60-cycle AC source. Set attenuator (in preamplifier being used) to 1 volt/div position. Insert the AC cord into the receptacle located on the rear of the MEMO-SCOPE oscilloscope cabinet, and plug other end into a 110-volt, 50/60 cycle socket. Turn POWER switch to POWER ON, and allow about one minute for MEMO-SCOPE oscilloscope circuits to warm up. Turn INT clockwise until a dim (minimum brilliance) trace on the CRT screen is visible. Center the trace with the V POS and H POS controls. If no trace is immediately visible when the INT is turned up, adjustment of the position controls should bring the trace on to the CRT screen. If a spot or vertical line instead of a sinusoidal trace is displayed, adjust the TRIG LEVEL to start operation of the sweep, so as to display the 60-cycle sine wave.

Turn on BLANKING ON switch (up position); retrace portion of the sweep should disappear. The MEMO-SCOPE oscilloscope is now operating as a standard oscilloscope, displaying the sine wave repeatedly so that it is visible as a stationary pattern.

2-5. Adjustment of Storage Controls: In order to cause the MEMO-SCOPE oscilloscope to store a trace, the FLOOD GUN switch must be turned ON, and the STORAGE controls must be properly adjusted. However, it is first necessary to replace the repetitive (periodic) display which is now appearing on the CRT screen with a single stroke ("one-shot") display. Proceed as follows:

a. With the line frequency sine wave displayed as in paragraph 2-4, and the BLANKING ON switch in the up position, set the TRIG SEL to EXT DC+. The display will disappear since there is no trigger on the EXT TRIG connector to trigger the sweep.

b. Obtain a battery having at least 1.5 volts potential, and connect its negative terminal to GND connector. Connect a lead to the EXT TRIG connector, and touch it to the positive terminal of the battery. Each time this lead is touched to the battery, the sweep should trigger, displaying one group of sine waves. It may be necessary to adjust the TRIG LEVEL control to provide proper triggering and to adjust the INT control for a visible trace.

c. Now that a single trace may be displayed by touching the lead to the positive terminal of the battery, the storage properties of the MEMO-SCOPE oscilloscope may be easily demonstrated.

d. Turn ON the FLOOD GUN switch.

e. Triggering the sweep with the battery will now display a trace that has a slightly longer persistence than that previously obtained. Now, slowly rotate the STORAGE control clockwise, and, at the same time, repeatedly trigger the sweep, using the battery. As the STORAGE control is rotated clockwise, the persistence of the trace will increase until a point is reached where the trace persists indefinitely.

f. Proper storage adjustment is with the STORAGE control turned to just above the point where the trace remains indefinitely, but below the point that causes a bright background.

2-6. TYPICAL OPERATION OF THE SWEEP CIRCUIT CONTROLS.

2-7. The operation of the sweep trigger adjustments is best illustrated by displaying a sine wave (without any trace storage) as described in paragraphs 2-4 and 2-5, preceding.

a. Adjust the amplitude of the sine wave to near full scale.

b. Rotating the TRIG LEVEL knob in the + quadrant will cause the sweep to trigger on the positive slope of the sine wave. Rotation in the - quadrant will cause the sweep to trigger on the negative slope of the sine wave.

When triggering from essentially square waves or pulses, select the "+" mode for triggering from the positive edge and the "-" mode for triggering from the negative edge.

IMPORTANT NOTE

Sometimes, when the period of the triggering waveform is near a submultiple of the sweep duration, the sweep will hang up or "jitter". This is due to the trigger occurring during the sweep retrace. Slight adjustment of the sweep speed will cure "jitter". When a steady signal (zero volts or otherwise) is applied to the sweep triggering circuits, and the position of the TRIG LEVEL happens to be in a certain position, it will be found that the sweep will remain far to the right of the CRT screen. This is due to the fact that the sweep is being continuously "triggered" by the steady potential. It will not return until the triggering potential is changed beyond the critical level selected by the TRIG LEVEL control, or until the TRIG LEVEL itself is changed. Since the blanking circuit prevents the beam from normally being seen in this irregular position, the SWEEP READY lamp is provided. This lamp will be off whenever the sweep is not in its left-hand starting position, ready to receive a trigger.

2-8. CONNECTION DIRECT TO THE MEMOTRON TUBE DEFLECTION PLATES.

2-9. If an auxiliary oscilloscope has sufficiently large deflection voltages (90 to 100 volts/inch), and has the proper average DC level (+200 volts), the deflection plates of the MEMOTRON tube may be directly connected. To make this connection, turn the equipment OFF, and remove the four links in the rear of the MEMOTRON tube that connect to the MEMO-SCOPE oscilloscope amplifiers to deflection plates DP1, DP2, DP3, and DP4. These links, and their relative positions are shown in figure 7 (high-voltage schematic).

Intensity modulation of the beam may be made through the CATHODE connection in the rear of the MEMO-SCOPE oscilloscope. Since the MEMOTRON tube is a bistable device, intensity modulation will only produce a series of dots and dashes without halftones. The cathode connection is suitable for moderately high frequency timing marks (time constant approximately 0.1 milliseconds).

2-10. MEASURING WRITING SPEED.

2-11. When viewing transients, the rise time often requires fast writing speeds of the MEMO-SCOPE oscilloscope. The writing speed of the MEMO-SCOPE oscilloscope when used as a conventional oscilloscope, is comparable to that of any comparable CRT screen. However, the writing speed in the STORAGE mode is inherently slower. The following technique can be used to measure writing speeds:

a. Test equipment required are an audio signal generator capable of generating sine waves of up to about 20,000 cps (to measure writing speeds to 200,000 inches/sec), or up to about 100,000 cps (writing speeds to one million inches per second), and a trigger which can be a battery fed resistor-capacitor network having a time-constant of less that 100 microseconds.

b. Place the MEMO-SCOPE oscilloscope in the non-storage mode (FLOOD GUN switch OFF, and STORAGE counterclockwise), adjust the signal generator to 12,500 cps, set the MEMO-SCOPE oscilloscope sweep to 10 microseconds per division, and adjust the amplitude of the displayed sine wave to 3.18 inches (slightly greater than the 3 by 3 inch grid over the screen of the MEMOTRON CRT).

c. Adjust the FOCUS and ASTIG controls to the finest line possible, remembering that the finer the trace, the faster the writing speed.

d. Switch to the storage mode (FLOOD GUN switch ON, and STORAGE control turned up as described in paragraph 2-5), change to EXT TRIG, and adjust the STORAGE control level until the trace is retained.

e. Now display a single trace, and increase the frequency of the signal generator until the trace around "zero" disappears; then reduce the signal generator frequency until the trace just reappears. This frequency, in cycles per second, multiplied by 10, is the writing speed in inches per second.

2-12. PRECAUTIONS IN USING THE MEMOTRON TUBE.

2-13. MEMOTRON tubes are an outstanding development of Hughes Products, and are unique in their ability to retain written traces, even at the high writing speeds previously discussed. These tubes have been developed and put into use over a period of several years.

Tests made at Hughes Products and at independent test laboratories show that the MEMOTRON tube, if used under the proper conditions, has a life of many thousands of hours. However, there are several ways

in which the MEMOTRON tube can be damaged, impairing its use, and/or reducing its normal life. Since the ways in which the MEMOTRON tube can be damaged may not be obvious to the new user, they are listed as follows:

Use of Excessive Writing Beam Intensity

This may permanently damage the storage screen of the MEMOTRON tube, by causing damaged areas which are no longer capable of storing traces, or resulting in burned phosphor areas on the screen of the tube. Good rules for preventing such damage are:

a. Keep the writing gun beam (INT) as low as feasible, compatible with the work you are doing (refer to paragraph 1-6).

b. Be particularly careful if the sweep rate is less than 10 milliseconds per division, or if there is no sweep at all.

c. Never use a beam so bright that there is a "halo" around the spot.

Damage in the Non-Storage Mode

The MEMOTRON tube is equally susceptible to damage in either the storage or non-storage modes of operation. Damage may occur with the tube in the non-storage mode, but not be apparent until when the tube is operated later in the storage mode.

Damage Due to Repetitive Traces or Signals

When used for demonstration purposes or other uses where the same identical trace is written, erased, written again in the same exact area many times, a "positive" area may result. In such an area, the area traced is brighter than the rest of the background, even after the trace is erased. This damage will only occur if such a repetitive trace is repeated for many hours or days.

Damage Due to Stored Traces Being Left on Screen

As outlined in paragraph 2-5, a trace may be displayed in the storage mode, the writing beam turned off (INT), and the trace will remain on the screen. If the trace is left this way for several hours, a temporary change in the MEMOTRON tube characteristics may occur on the areas where the stored trace has been displayed. This may result in a temporary "positive" area as described just preceding, which will usually disappear within a day or so.

Field Emission Spots

Occasionally, bright spots may appear on the MEMOTRON tube screen. These spots are due to a momentary, localized breakdown. Such spots usually burn out within a matter of minutes, and do not cause any permanent damage to the MEMOTRON tube. They are known as "Field Emission" Spots.

Because all MEMOTRON tubes are aged before installation in any MEMO-SCOPE oscilloscope, few cases of Field Emission occur after the MEMO-SCOPE oscilloscope is delivered. Those which do occur, disappear within a very short time.

Damage Because of Burned Areas

Areas that have been burned are not capable of storing traces; there is no way such areas can be repaired.

If the burn is very heavy and extensive, there may be some tendency for the burn to spread slightly. The other areas will not otherwise be affected by the burn, and will write and store as before.

Damage to the Phosphor

The phosphor is the same as on the conventional CRT, and, of course, is more difficult to damage than the storage screens. If the precautions for protecting the storage screens given above are followed, the phosphor will not be damaged.

NOTE

To reduce the possibility of damage to the MEMOTRON tube, it is recommended that the following shutdown procedure be used before POWER switch is turned OFF:

1. Depress ERASE button.
2. Turn STORAGE control all the way counterclockwise.
3. Turn FLOOD GUN switch OFF.
4. POWER switch may now be turned OFF.

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SECTION III
CIRCUIT DESCRIPTION

3-1. DETAILED DESCRIPTION OF MEMO-SCOPE OSCILLOSCOPE MODEL 104-D CIRCUITS.

NOTE

The circuit descriptions for the speed enhancement circuit, each of the three preamplifiers available, and the two probes, are contained in SECTION V, ACCESSORY EQUIPMENT.

3-2. SWEEP CIRCUITS. (See figure 4.)

3-3. Trigger Amplifier: Tubes V201 and V202 comprise a cathode-coupled amplifier for producing amplified positive and negative trigger signals. The TRIG SEL switch, S1A, selects the triggering mode, and switch section S1B selects the trigger slope polarity.

In the EXT TRIG position of the TRIG SEL switch, the grid of V201 is connected directly to the EXT TRIG connector, J9. The grid of V202 is adjustable in level by the TRIG LEVEL control, R12. The external trigger balance adjustment, R14 (see "A", figure 9), adjusts the TRIG LEVEL to read 0 (central position) when triggering of the sweep from near the zero axis of the triggering waveform is desired. This adjustment may be made by applying a triggering signal of 0.5 volt amplitude from the CAL OUT terminal to the EXT TRIG connector. With the sweep adjusted for 1 millisecond per division, TRIG SEL on EXT DC, adjust the TRIG LEVEL for proper sweep triggering. Note the position of the TRIG LEVEL, and adjust the external trigger balance until the sweep is properly triggered with the TRIG LEVEL control at zero center. The TRIG LEVEL should now cause the sweep to trigger at any desired level of the EXT TRIG waveform between approximately +10 and -10 volts.

When the TRIG SEL is set on INT AC, the trigger signal is obtained from the vertical amplifier in the preamplifier being used (Section V) through an RC network, 22 megohm resistor, R2, and 47 mfd capacitor, C2, and decoupled by 0.002 mfd capacitor, C52 (see figure 4). The sensitivity of the trigger amplifier is sufficient to cause triggering on a signal providing less than two divisions (1/3 inch each) deflection on the MEMOTRON tube screen. When on INT DC triggering, the preamplifier signal is directly connected.

In order that the TRIG LEVEL indicates near zero when triggering occurs near the zero volt level of the signal. the internal trigger balance adjustment, R16 (see "B", figure 9) is provided. This adjustment is made using a 1.0 volt square wave from the calibrating output (CAL OUT connector on front panel) to the vertical input on the preamplifier being used. With the vertical attenuator VOLTS/DIV adjusted for about two scale divisions vertical deflection on the MEMOTRON tube screen, set TIME/DIV on 1 millisecond. Note the position of the TRIG LEVEL control for proper triggering, and adjust the internal trigger balance, R16, until the sweep is properly triggered with the TRIG LEVEL control near zero center.

3-4. Linear Sweep Generator: The amplified trigger is applied to the grid of V203A. V204 is connected as a bi-stable multivibrator or "toggle". When the grid of V203A is sufficiently positive, plate current flows, and causes V204B to cut-off and V204A to conduct. The toggle remains in this state for the duration of the sweep.

As soon as the toggle is triggered, V205A is cut-off by the negative voltage appearing at the cathode of V204B due to the bleeder, R25, to the -200 volt supply, and V204B being cutoff. The diode, V208A, provides a small delay at the end of the sweep period, and the crystal, CR7, clamps the cathode at ground when V204B is conducting.

When V205A is cut-off, the timing capacitor selected by the TIME/DIV control, S2B, begins to charge from current supplied through the resistor selected by the SWEEP MULT control, S3.

The charging current is kept constant by a modified bootstrap circuit consisting of V206A, V207, and V205B. Cathode follower, V206A, maintains its grid-cathode potential within 1 volt over the full 90-volt amplitude of the sweep sawtooth applied to its grid. The charging current to the timing capacitor is proportional to the voltage across the charging resistor. This voltage is made up of the voltage across the regulator tube, V207, plus the grid-cathode bias of V206A. Since the latter is very nearly constant, due to the cathode-follower action, the charging current remains constant, and the resultant sweep rate is linear.

V206B maintains constant plate voltage for V206A, and V205B maintains a constant cathode current for V206A, thus improving the cathode-follower action and the linearity of the sweep.

When the sweep voltage reaches approximately 90 volts at the cathode of V206, the voltage at the grid of V203B (which is obtained from the divider consisting of R37,

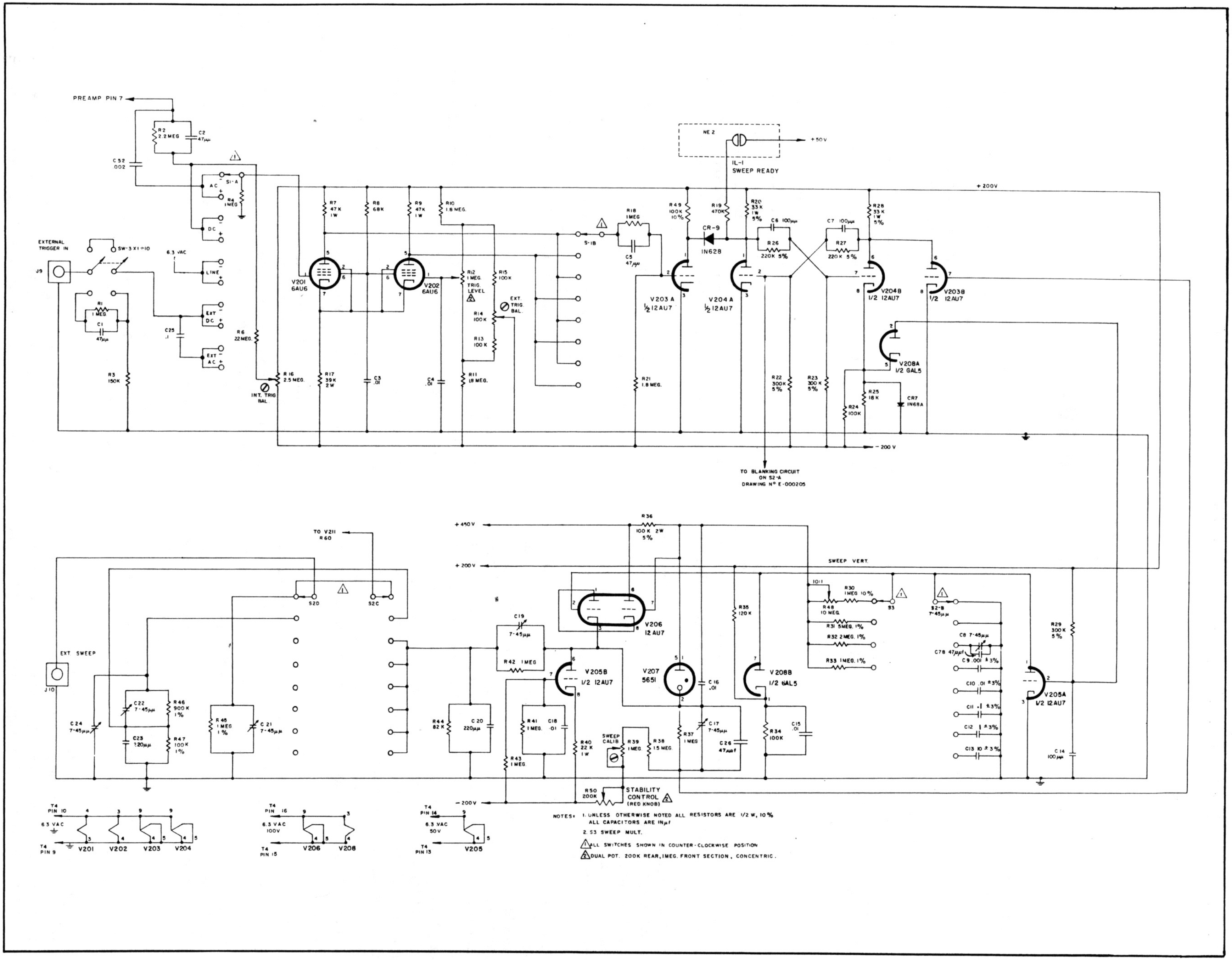


Figure 4. Schematic, Sweep Circuits

R38, and the sweep calibration adjustment, R39; see "D", figure 9) becomes sufficiently positive to cause V203B to conduct. The toggle, V204, is caused to flip through the action of plate of V203B. V204B conducts, its cathode rises to ground level, causing V205A to conduct after a short delay caused by R29 and C14. The plate resistance of V205A discharges the timing capacitor, thus producing the sweep retrace. The sweep is then ready to receive another trigger.

The time delay in the plate circuit of V208A allows the toggle to be reset by V203B before the timing capacitor is discharged and V203B is cut-off.

Trigger pulses occuring during the sweep period have no effect once the toggle is set. However, if at the end of the sweep the trigger waveform is still holding V203A conducting, the toggle cannot be reset by V203B, and the sweep continues until "caught" by the diode, V208B, and held at the right hand side.

The sweep will return to the starting position at the left when the trigger waveform allows V203A to cut-off. Under conditions where the sweep is held at maximum voltage, the beam on the CRT will still be blanked, since V203B will hold the grid of V204A negative, and therefore turn off the beam by means of the blanking circuit (refer to paragraph 3-5). When the sweep is purposely held in this state, the SWEEP READY lamp, IL1 will remain out.

The exact amplitude at which the sweep is terminated is adjusted by means of the sweep calibration potentiometer, R39 (see "D", figure 9). This adjustment is made to produce a sweep time of exactly 100 milliseconds when the sweep selector is set for 10 milliseconds per division sweep. The sweep time can be measured by applying a suitable known frequency to the vertical amplifier. For example, a 100-cycle wave should appear as exactly 10 full cycles across the screen, from the start to the end of the sweep.

Capacitor C19 (see figures 4 and 9) is adjusted on the highest sweep speed to produce an undistorted sweep waveform at the grid of V203B. The grid waveform may be observed on the MEMO-SCOPE oscilloscope itself by using a low-capacity probe. Proper adjustment is indicated by a straight line sloping up to the right of the screen.

The sweep voltage at the cathode of V206 is divided down to approximately 9 volts amplitude by R42 and R44, and thence to the horizontal amplifier via switch section S2C. Capacitor C19 (see figure 4 and 9) is adjusted for faithful reproduction at the start of the fastest sweep (10 MICROSECS position of TIME/DIV switch) at the input of the horizontal amplifier.

3-5. BLANKING CIRCUIT. (See figure 5.)

3-6. It is important in a MEMO-SCOPE oscilloscope to keep the writing beam turned off except during the sweep time, to avoid gradual build-up of the spot diameter and background due to the storage action. The MEMOTRON CRT beam is therefore automatically turned on by an unblanking circuit which is directly coupled to the CRT control grid. Direct coupling allows the beam to be turned on at constant intensity for long periods of time as is required on the lowest sweep rates.

The beam is blanked by applying a negative voltage between grid and cathode of the MEMOTRON tube writing gun. Since the writing gun cathode is necessarily at about -3000 volts, direct coupling is more readily accomplished by a high frequency carrier transmission system then by actual direct resistance coupling.

Blanking is accomplished by V210, which is a self-excited oscillator operating at approximately 10.5 mc. The oscillator is keyed on and off in step with the sweep functions of the MEMO-SCOPE oscilloscope. The grid of V204A (see figure 4) supplies the gate signal. This gate is amplified by V209A and V209B, and applied as a bias to V210. The power from the blanking oscillator is coupled to a low-impedance, twisted-pair, transmission line, and fed to a receiving coil and capacitor, C130 and T2 (see figure 7), which is tuned to the oscillator frequency. This receiving section is located in the High-Voltage Power Supply (see figure 11).

The voltage appearing across the secondary of T2 (figure 7) is rectified and doubled by means of V607, and applied as a "back voltage" in series with the arm of R265 to the grid of the MEMOTRON tube.

The filament of V607 is supplied by T4 pins 17 and 18, insulated for 3000 volts. These same pins supply the MEMOTRON tube writing gun filament. The filament line to V607 is carried to the tube by means of pin jacks on the top of the high-voltage power supply. These pins are not polorized.

The blanking oscillator, V210, is a standard Colpitts, using a paralleled dual triode. The oscillator may be keyed on and off by applying a negative voltage to the control grid. The negative voltage is an amplified inversion of the positive square wave appearing at the grid of V209A. When the grid of V209A is positive, the oscillator is turned off by the cathode follower V209B, and the MEMOTRON tube writing beam is turned on.

When the MEMO-SCOPE oscilloscope sweep is being used, the positive square wave applied to the grid of V209A via switch section S2A is the blanking gate derived from the grid of the toggle, V204A. This grid

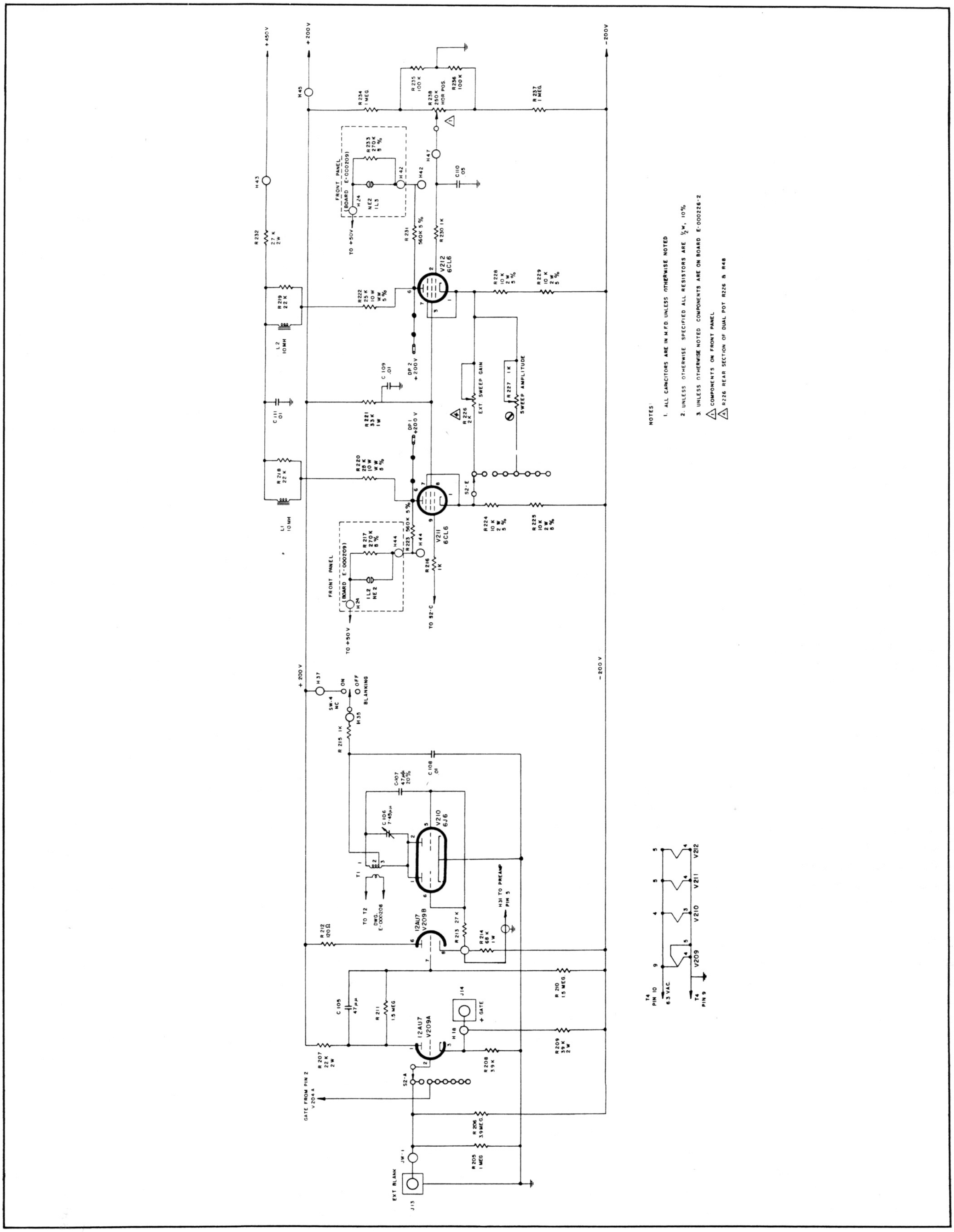


Figure 5. Schematic, Blanking and Horizontal Amplifier

is positive for the duration of the sweep, and becomes negative immediately as the sweep terminates and V203B conducts.

When an external sweep is being used, the grid of V209A is connected to the EXT BLANK connector, J13, and to a bias network that normally cuts off V209A with about -20 volts. Raising the potential of the EXT BLANK connection to about 0 volt will turn off the blanking oscillator, and turn on the MEMOTRON tube writing gun.

Occasionally, such as when adjusting the beam for proper intensity (INT), or when blanking is not used, it is desired to remove the blanking signal. Positioning the BLANKING ON switch, S4, to its down position removes the DC voltages from the blanking oscillator, thus preventing it from being turned on and allowing the MEMOTRON tube beam to be displayed continuously.

The + GATE is obtained from the cathode of V209A. This waveform is useful to trigger external circuits from the MEMO-SCOPE oscilloscope sweep. When the trace is being displayed, the voltage at the + GATE connection is 0 volts. During flyback and waiting time, the voltage is approximately -20 volts. It is to be noted that a suitable trigger must still be used to initiate the sweep.

3-7. HORIZONTAL AMPLIFIER. (See figure 5.)

3-8. V211 and V212 comprise a cathode coupled, paraphased amplifier to produce push-pull voltages for the storage tube horizontal deflection plates. The amplifier is normally used to amplify the sweep voltage from the sweep generator, but may be switched to the EXT SWEEP input for amplifying special sweep waveforms. The two modes are selected by the TIME/DIV control, switch sections S2C and S2D. Section S2C connects the input grid to either the sweep output across R42, or to one of the external sweep attenuators on switch section S2D. Section S2E connects either the SWEEP AMPLITUDE, adjustment, R227 (see "E", figure 9), or the external sweep gain potentiometer, R226 (ganged with the SWEEP 10:1 control) between the cathodes of V211 and V212. These gain controls vary the gain of the amplifier by introducing degeneration in the cathode circuit.

The Sweep Amplitude adjustment, R227, is adjusted so as to cause the linear sweep to occupy exactly 10 divisions across the screen of the MEMOTRON tube.

The External Sweep Gain, R226, is a fine gain control for the external sweep, and provides and approximately 10:1 variation in gain. Further gain variation for the external sweep is provided by the attenuator on switch section S2D which provides an additional 10:1 attenuation. This attenuator is designed to provide a 50 mmf input capacity and 1 megohm input resistance. It will be noticed that adjustment of the external sweep gain or the sweep amplitude will produce a horizontal shift in the position of the MEMOTRON tube trace; the magnitude of this shift depends upon the position of the H POS control. This shift happens because the amplifier is unbalanced except for the position of the H POS control that makes the cathodes of V211 and V212 equal in potential.

3-9. VERTICAL AMPLIFIER. (See figure 6.)

3-10. V501 and V502 comprise a cathode coupled amplifier to produce push-pull voltages used to drive the vertical deflection plates of the MEMOTRON tube. The input is push-pull from the preamplifier, through pins 8 and 16 on the connector at the rear of the preamplifier. The vertical amplifier gain is adjusted at the factory so that a signal input of 9 volts peak-to-peak amplitude will produce full-scale deflection on the MEMOTRON tube.

3-11. STORAGE TUBE SPECIAL CIRCUITS.

3-12. Contrast Enhancement Oscillator: The blocking oscillator, V302 (see figure 6) develops 10 microsecond pulses at about a 1000 cps rate across the 250-ohm potentiometer R74, in the cathode of V302. These pulses have an amplitude of about +15 volts, and are applied to the storage mesh of the MEMOTRON tube. This pulsed voltage improves the contrast of the stored traces by decreasing the background brightness.

3-13. Erase Circuit: V303 (see figure 6) provides a high impedance source for the MEMOTRON tube collector mesh. The potentiometer R81 (STORAGE control on front panel of the MEMO-SCOPE oscilloscope) provides means for adjusting the current in the first section of V303, which adjusts the plate voltage level (and consequently the MEMOTRON tube collector mesh voltage) in the second section of V303.

Either depressing the ERASE pushbutton, SW5, or grounding the external ERASE connection, J16, momentarily reduces the collector voltage on V606 to nearly zero. In addition, the plate voltage of the second section of V303 is reduced to nearly zero, and the voltages of the grids of V302 are dropped to below -25 volts, blocking the contrast enhancement oscillator. After releasing the ERASE pushbutton or removing the ground from the external ERASE connector, capacitor C46 is recharged from the +450 volt supply through resistor R80, gradually restoring the grids of the contrast oscillator V302, until V302 is again functioning, and restoring the MEMOTRON tube to the storage mode. Time for complete erasure is approximately one second.

3-14. Calibration Voltage: The square wave for the calibrated voltage at the CAL OUT connector, J15, on

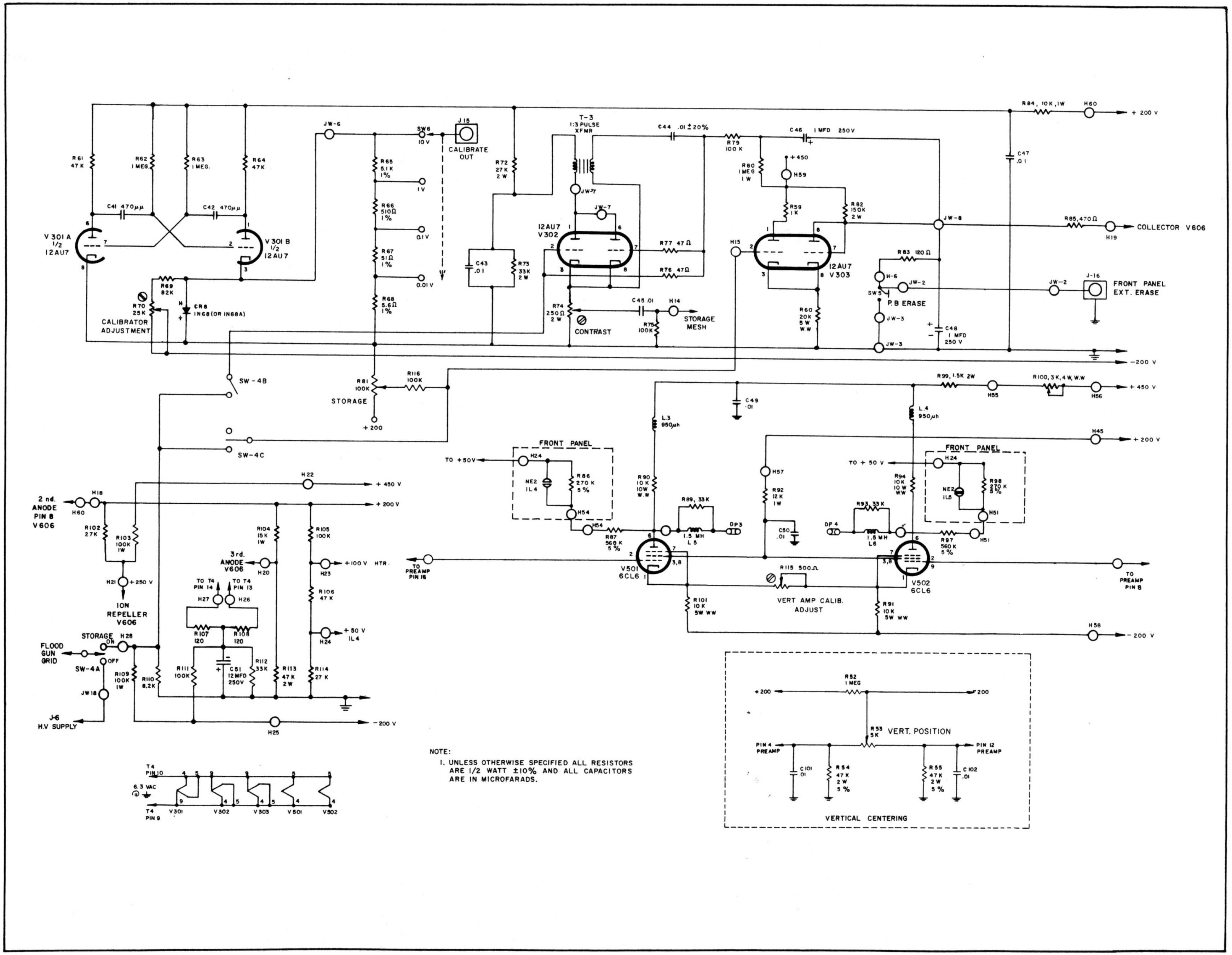


Figure 6. Schematic, Calibrate Voltage, Storage Circuit, and Vertical Amplifier

the front panel of the MEMO-SCOPE oscilloscope is generated by a multivibrator formed by V301A and V301B. This free-running multivibrator has a frequency of approximately 1000 cps, and its cathode-follower output is applied across the calibration voltage dividing network, R65, R66, R67, and R68 (see figure 6). The CALIB VOLTS switch, SW6 (on front panel of MEMO-SCOPE oscilloscope), selects which portion of the network is connected to the CAL OUT jack: 0.01, 0.1, 1, or 10 volts. The calibration adjustment potentiometer, R70 (see "H", figure 9), provides for a fine adjustment of the calibration voltage level.

When V301B is cut-off (V301A conducting), the side of CR8 which is connected to the cathode of V301B is below ground potential (as determined by the -200 volt bias supply), and current flows through R70 and R69 through CR8 to ground; the cathode of V301B is thus clamped to ground, effectively shorting out the calibration voltage network.

When C41 stops discharging sufficiently through R62, permitting the grid of V301B to go positive, V301B will conduct (and shut off the V301A side of the multivibrator) and the cathode of V301B will go positive (additional current flow through R70 and R69). The cathode of V301B will not become immediately positive with respect to ground, as it will stay at ground potential until the current flow through resistors R70 and R69 is sufficient to raise cathode of V301B above ground potential; at this point, CR8 can no longer conduct, and a positive-going voltage begins to appear across the calibration voltage network (cathode current flow through dividing network to V301B). This positive-going voltage will continue to increase until V301B shuts off. Note that V301B will shut off as determined by the rate at which C41 discharges through R62 (creating a negative-going voltage at the grid of V301B), plus the advance negative bias established by the current flow through R70 and R69 (from -200 volt supply). Thus, this self-cancelling bias establishes the cutoff point of V301B, or, to the point, the maximum voltage that can appear across the calibration voltage network, R65, R66, R67, and R68.

3-15. HIGH VOLTAGE POWER SUPPLY. (See figure 7.)

3-16. The high voltage power supply provides +4.5 and -2.85 kilovolts for the viewing screen and writing gun cathode of the MEMOTRON tube, as well as bias (intensity) and focus voltages for the writing gun.

V602 and V603 comprise a parallel rf oscillator operating at about 300 kc. The oscillator transformer, T5, steps up the rf voltage sufficiently to allow the diode, V604, to supply +4.8 kilovolts, and diode V605 to supply -2.85 kilovolts. The +4.5 kilovolts is supplied directly to the MEMOTRON tube viewing screen through the filter network C119, C120, and R267, and the series resistor, R268.

The -2.85 kilovolts is filtered by C118, C221, and R266, and divided down by a bleeder to +200 volts. The INT control, R265 (see "B", figure 11), provides bias control for the MEMOTRON tube writing gun. The tuned circuit T2 and C130 and the 6AL5 diode, *V607, comprise the blanking circuit described in paragraph 3-6.

A tap at -2600 volts is provided for the writing gun cathode. Resistor R272 and capacitor C129 provide an external connection (CRT CATH on deflection plate board) for intensity modulating of the writing beam. The FOCUS control, R263 (see "A", figure 11) provides control for proper first anode potential on the MEMOTRON tube for focus.

A tap at ground potential point of the bleeder (R260 through R265) supplies a control voltage for regulating the high voltage supply. This voltage is amplified by the two-stage amplifier, V601, and controls the screen voltage of the rf oscillator tubes. When the screen voltage on the tubes is lowered, the oscillator output decreases, lowering the high voltage. The amplifier maintains the screen at the proper potential to supply a constant -2.85 kilovolts at the CRT CATH connection.

The High Voltage Adjustment, R258 (see "C", figure 11), allows the -2.85 kilovolts to be adjusted to its correct value.

*NOTE: Older models use two IN68A crystals instead of a 6AL5 tube.

C116 tunes the rf oscillator plate circuit to the resonant frequency of the high voltage secondary. Proper adjustment is indicated by minimum screen voltage on V602 and V603.

3-17. LOW VOLTAGE POWER SUPPLIES. (See figure 8.)

3-18. The low voltage power supply uses six silicon rectifier voltage doublers (CR1 through CR6).

V401A is a series regulator tube for the +450 volts, and V403 is the regulator amplifier.

V401B and V402B are the series regulators for the +200 volts. The two-stage direct-coupled amplifier V405 and V404 provide high gain for close regulation of the +200 volt supply.

V402A is a series regulator for the -200 volt supply. V409 and V406 comprise an amplifier similar to the +200 volt regulator amplifier, with similarly high gain. V407 supplies a constant potential for the cathode of V406. V408 is the voltage reference for the -200 volt supply. All the other regulated supplies are referenced to the -200 volt supply.

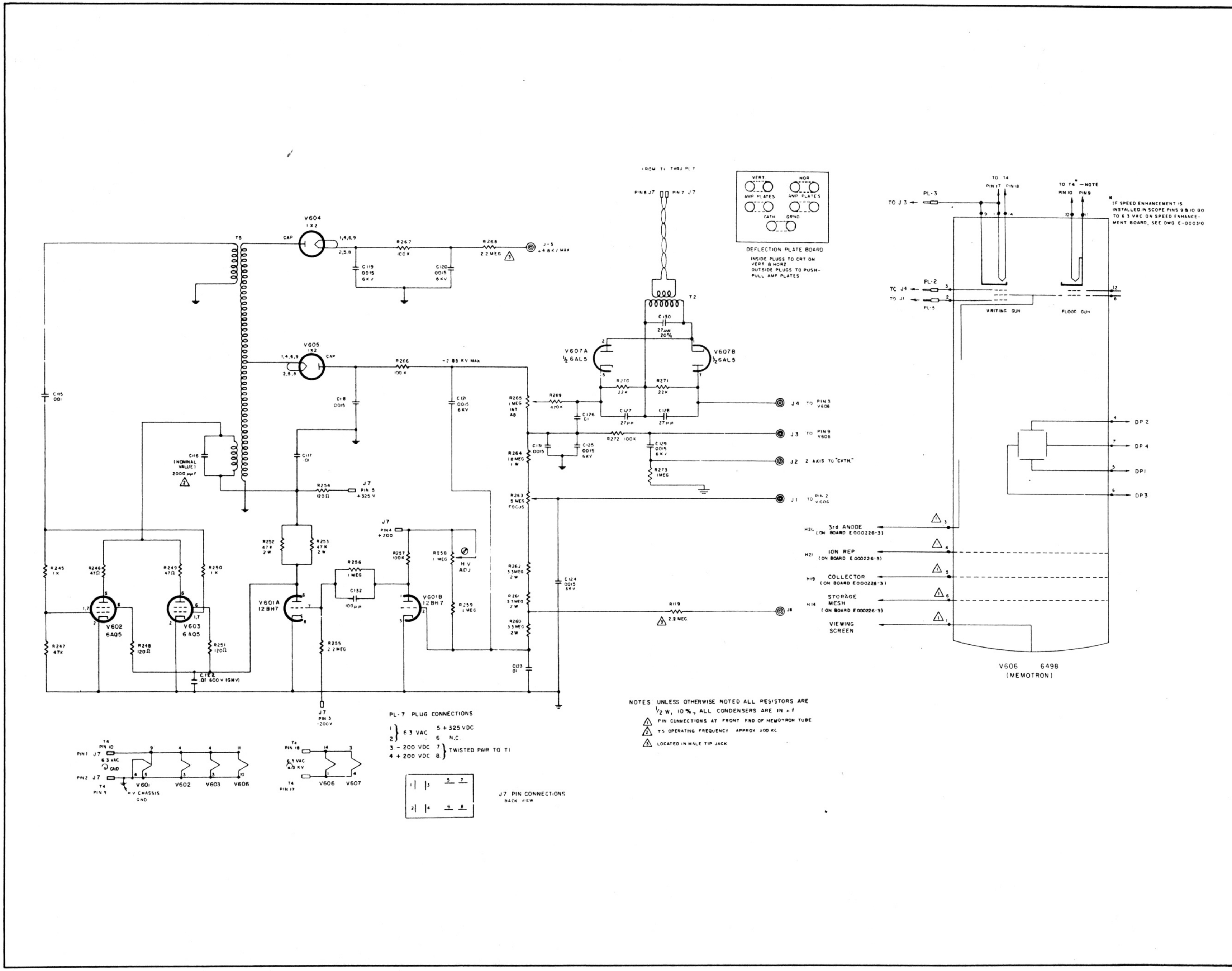


Figure 7. Schematic, High Voltage Power Supply and MEMOTRON Tube

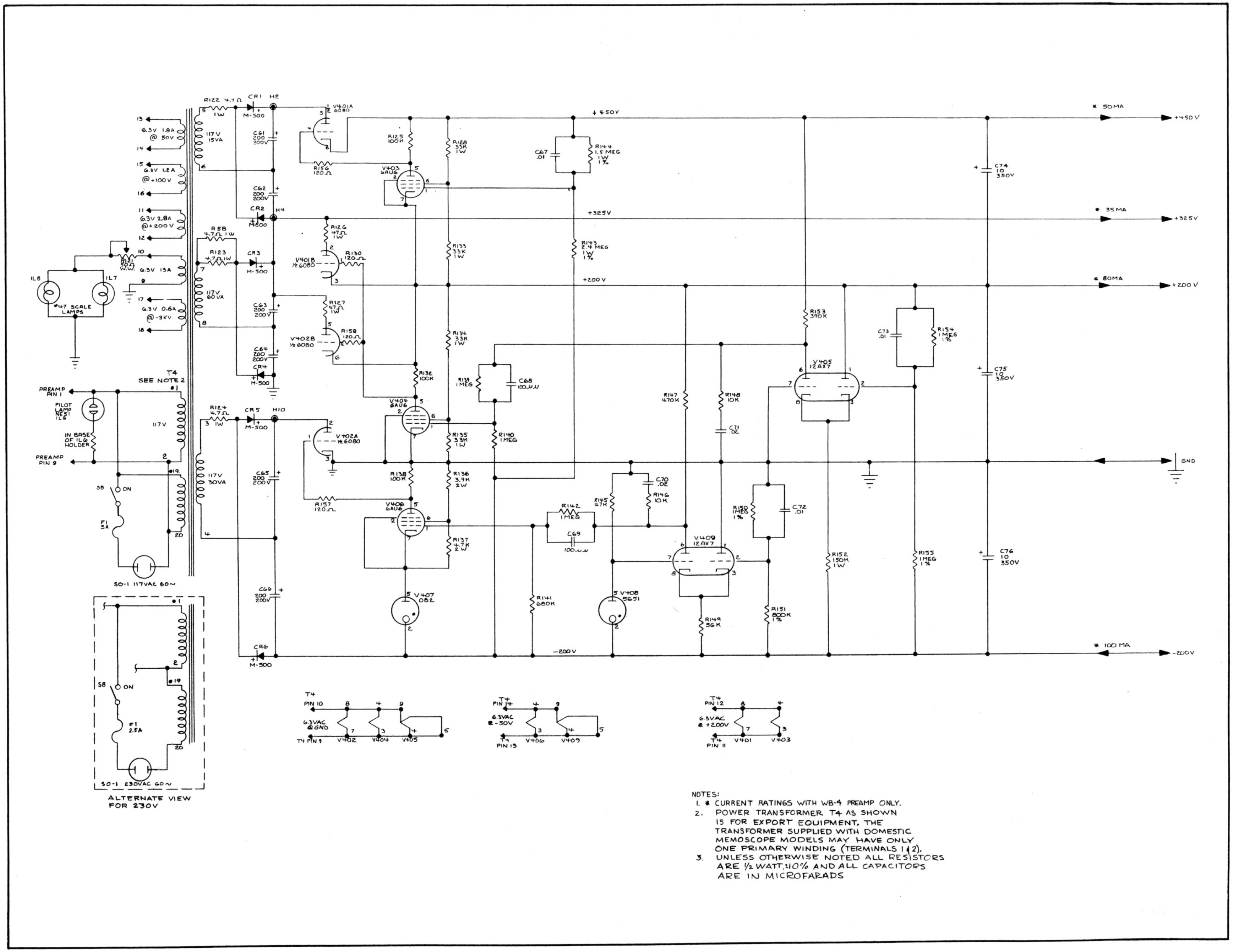


Figure 8. Schematic, Low Voltage Power Supply and Regulators

+325 volts for the high voltage rf oscillator (refer to paragraph 3-16) is supplied from the input to the +200 volt regulator.

3-19. EXTERNAL SWEEP ATTENUATOR. (See figure 4).

3-20. The external sweep attenuator, consisting of switch sections S2C, S2D, on the TIME/DIV control on the front panel, has three trimmer capacitors, C21, C22, and C24 (see figure 4). These trimmers should be adjusted to provide a flat frequency response and a constant input capacity. The adjustments are made in a similar manner as the preamplifier adjustments, which should be made first (refer to Section V).

Apply a linear sweep to the vertical amplifier from a sweep generator, and apply a 10 kc square wave to the EXT SWEEP input. Adjust the sweep to display the square wave on a vertical axis. With the EXT SWEEP attenuator in the X10 position, adjust C22 for optimum square wave response.

It is convenient to have the same input capacity on the EXT SWEEP input as on the VERT INPUT so that a low capacity probe may be used on either input without adjustment. The EXT SWEEP input capacity can be adjusted as follows:

a. Connect the probe, after it has been properly adjusted, to the EXT SWEEP input.

b. Connect the square wave generator to the probe, and again display the square wave.

c. With the EXT SWEEP attenuator at X10, adjust C24 for optimum square wave response.

d. Change the attenuator to X1, and adjust C21 for optimum square wave response. The attenuator is now properly adjusted.

3-21. MEMOTRON STORAGE TUBE. (See figures 2 and 8.)

3-22. The storage feature of the MEMOTRON tube is made possible by means of a storage mesh which is located immediately behind the viewing screen. Electrically charged wherever the dielectric is struck by the writing beam, the storage mesh retains the charged pattern, just as if it were locked in place.

Another mesh located directly behind the storage mesh has a positive potential applied to it for the purpose of collecting secondary electrons, thus preventing these electrons from neutralizing or cancelling the charge which the writing beam has deposited on the storage mesh. This mesh is identified as the Collector mesh in figures 2 and 7.

The stored image is achieved by the secondary emission characteristics of the storage mesh, and is continuously reproduced by a low-velocity beam of electrons from the flood gun in the MEMOTRON tube. The stored trace is visually displayed on the phosphor coated screen of the MEMOTRON tube as a result of the flood electrons. These electrons are emmitted through the charged areas, and receive additional energy from a post-accelerating potential which is applied to the viewing screen.

SECTION IV
MAINTENANCE AND SERVICE INSTRUCTIONS

4-1. MECHANICAL DISASSEMBLY.

4-2. To Remove Cover: The MEMO-SCOPE oscilloscope side covers are made in two identical parts, left and right. Each side is removed by loosening the two screws on each side, and then pulling the sides straight out and up from each side, until they are out of the channel.

The entire bottom can be removed by removing the four screws and rubber feet; the bottom is then pulled straight down and out.

4-3. To Remove High Voltage Power Supply: As shown in figure 11, the high voltage power supply is a complete subassembly, which may be removed from the MEMO-SCOPE oscilloscope chassis as a unit. To remove this unit, proceed as follows:

a. Disconnect the Jones plug and high voltage jacks on the top of the High Voltage Power Supply.

b. Remove the plug-in preamplifier so as to obtain access to the shafts leading from the power supply to the INT and FOCUS controls on the front panel.

c. Remove the four screws on the bottom of the power supply. Disconnect the two shafts.

d. Loosen the clamp on MEMOTRON tube to allow vertical clearance for high voltage box removal.

e. Slide the power supply out the side of the MEMO-SCOPE oscilloscope.

f. The front cover, top cover, and the etched circuit board may now be removed from the power supply.

4-4. To Remove the MEMOTRON Tube: The MEMOTRON tube can be removed from the MEMO-SCOPE oscilloscope as follows:

CAUTION

The MEMOTRON tube is specially made to produce its storage effect, and is thus very expensive, and should be handled with extreme care. NEVER CARRY THE MEMOTRON TUBE WITH ITS SCREEN DOWN. Keep the screen up or the axis of the tube horizontal to prevent any loose particles which may be inside the tube falling into the delicate storage mesh.

a. Remove the bezel and reticle in front of the MEMOTRON tube (attached to front panel of MEMO-SCOPE oscilloscope).

b. Loosen the clamping screw on the clamp located at the tube base. Push the MEMOTRON tube back slightly so that the cap connections on the front are clear of the support ring.

c. Disconnect all caps; rotate the tube if necessary to gain access to the caps.

NOTE

Be sure to note position of caps on the MEMOTRON tube as removed so that the MEMOTRON tube will be replaced in the same position at reassembly, and connections will be to the correct caps.

d. Pull the MEMOTRON tube forward about one inch.

e. Unplug the socket from the base. The tube is now removed by sliding it out through the hole in the front panel of the MEMO-SCOPE oscilloscope.

NOTE

Be sure that the high voltage connection pin on the front of the tube (normally at top when installed) aligns with the slot in the mounting ring so that the MEMOTRON tube will slide out easily.

4-5. Installation of MEMOTRON Tube: Installation of the MEMOTRON tube is carried out in the reverse order of procedure in paragraph 4-4:

a. Slide the tube, base first, through the hole in the front panel of the MEMO-SCOPE oscilloscope, through the magnetic shield, and rear clamp.

b. Connect the socket to the base.

c. Connect the front cap connections, rotating the tube as necessary for easy access.

NOTE

The high voltage cap must be at the top of the MEMO-SCOPE oscilloscope in its final position as shown in figure 13. The high voltage cap is easily located: It lies between the two dummy caps, 2 and 7 (no connection). Its proper position is directly on top. The high voltage cap is number 1; the other caps are numbered in sequence, through number 7, counting clockwise as shown in figure 13.

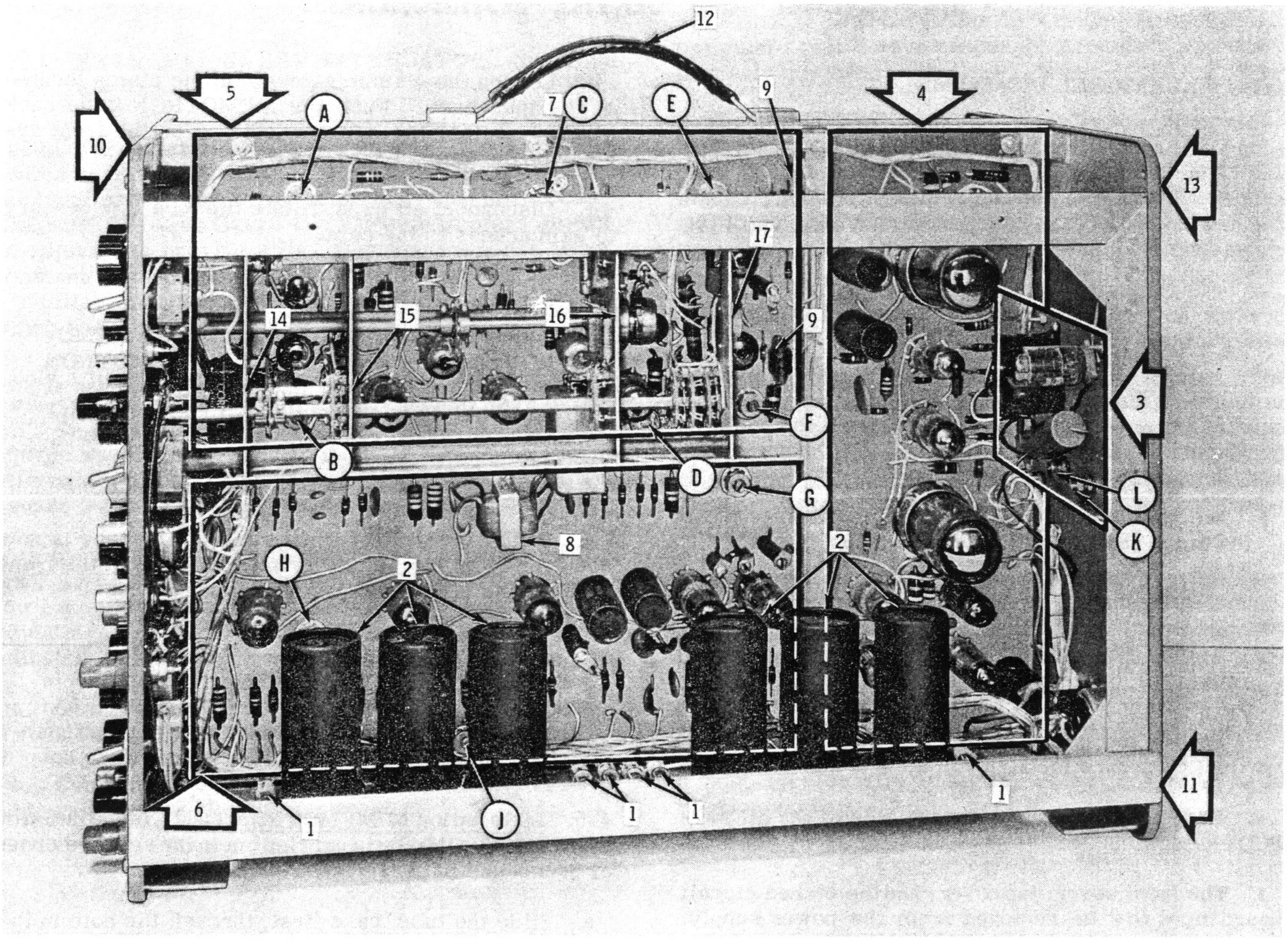


Figure 9. Right-Hand Side View, Model 104-D

KEY TO FIGURE 9:

1. Power Rectifiers, Silicon, Sarkes Tarzian, M500 - 1N1084
2. Filter Capacitor, Pyramid, Type ATM, 200-200 MFD, 200V
3. Speed Enhancement Circuit (Optional Accessory - refer to Section V), HAC No. E-000147
4. Low Voltage Regulator Board Assembly, HAC No. E-000131
5. Blanking Horizontal Amplifier Board Assembly, HAC No. E-000205

KEY TO FIGURE 9 (Continued):

6. Storage and Vertical Amplifier Board Assembly, HAC No. E-000204
7. Blanking Coil Oscillator, HAC No. E-000202
8. Pulse Transformer Blocking Oscillator, Gramer Halderson No. 383 W 11
9. 10 mh Chokes, Plate Circuit V211 and V212, RF501
10. Front Panel, HAC No. E-000104
11. Frame, HAC No. E-00101-1
12. Handle Assembly, HAC No. E-000141
13. Rear Panel, HAC No. E-000101-6
14. Sweep Board No. 1 Assembly, HAC No. E-000228
15. Sweep Board No. 2 Assembly, HAC No. E-000229
16. Sweep Board No. 3 Assembly, HAC No. E-000230
17. Sweep Board No. 4 Assembly, HAC No. E-000231

ADJUSTMENT POINTS

A. External Trigger Balance, R14

B. Internal Trigger Balance, R16

C. Blanking Adjustment, R100

D. Sweep Calibration Compensation, C17

E. Sweep Amplitude, R227

F. Sweep Calibration, R39

G. Vertical Calibration, R115

H. Calibration Adjustment, R70

J. Contrast, R74

K. Enhancement Pulse Amplitude (see Speed Enhancement, Section V)

L. Writing Speed Adjustment (see Speed Enhancement, Section V)

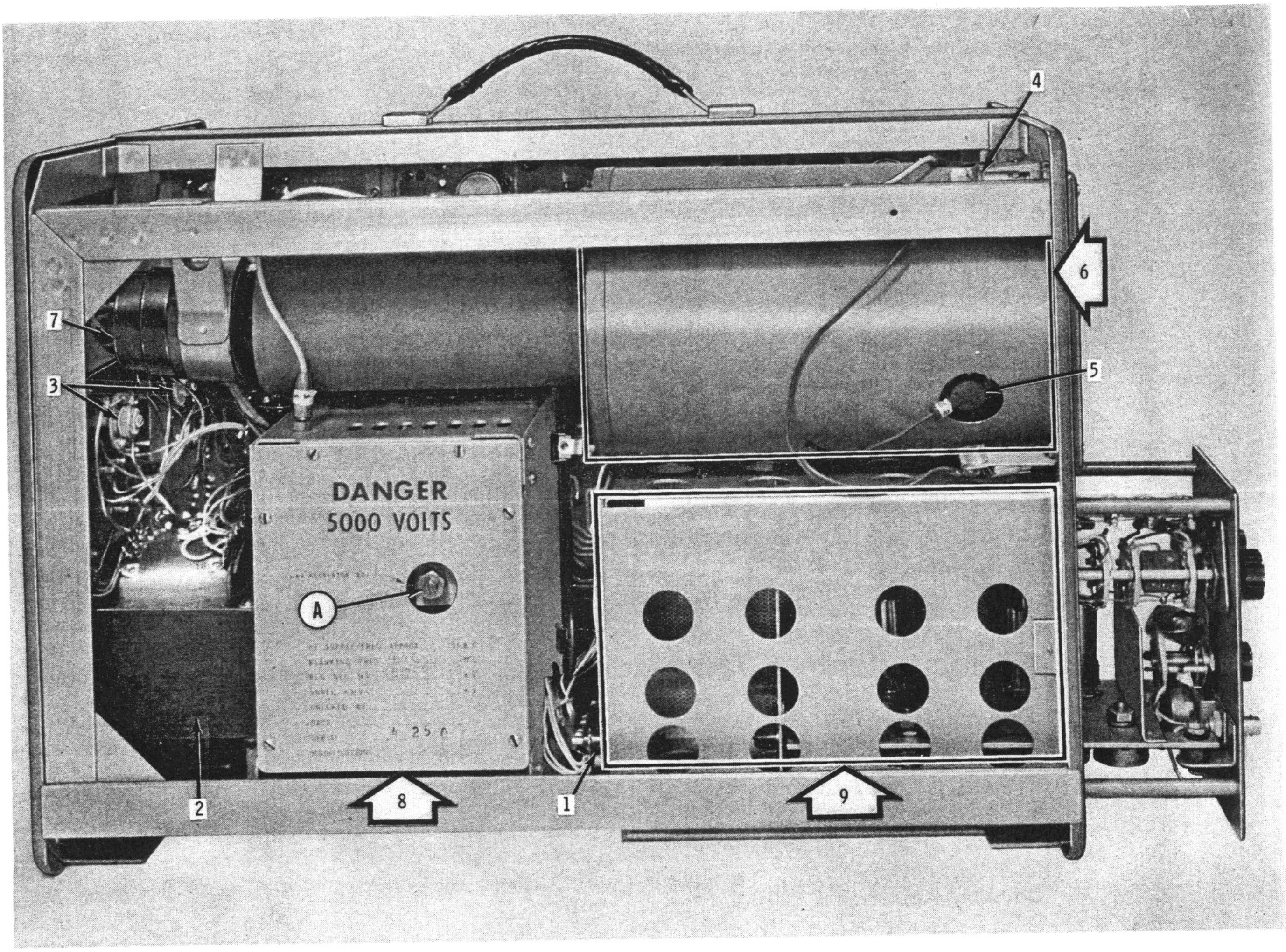


Figure 10. Left-Hand Side View, Model 104-D

d. Screw the reticle and bezel in place on the front panel with the four screws.

e. Push the MEMOTRON tube forward so that the face of the tube touches the scale.

f. Turn ON the MEMO-SCOPE oscilloscope, and check the trace alignment with the horizontal lines on the scale. If necessary, rotate the MEMOTRON tube slightly to align trace with scale.

g. Tighten the base clamp.

4-6. <u>To Remove MEMOTRON Tube Shield</u>:

a. Remove the sides (paragraph 4-2) and preamplifier.

b. Remove the four screws holding the preamplifier case in place, and pull it forward as far as the cable will permit.

c. Remove the jacks from the High Voltage Power Supply.

d. Disconnect the shaft couplings (to front panel) in High Voltage Power Supply.

KEY TO FIGURE 10:

1. Amphenol Connector, 26-159-16
2. Power Transformer, T4, HAC No. 000222
3. 1.5 mh Chokes, L6 and L5 (L5 hidden in this view)
4. MEMOTRON Tube Screen Anode, MEMOTRON Pin No. 1 (refer to figure 7)
5. 3rd Anode, MEMOTRON Tube Pin No. 3 (refer to figure 7)
6. MEMOTRON Tube Shield, HAC No. E-000108
7. Diheptal Socket, HAC No. E-000247, Jones 3B-4
8. High Voltage Power Supply Assembly (see figure 11)
9. Preamplifier Case

ADJUSTMENT POINTS

A. High Voltage Adjustment, R258

e. Remove the four screws in the bottom of the High Voltage Power Supply, and pull that unit out the side.

f. Remove the screw on the top front of the tube shield.

g. Rotate the MEMOTRON tube shield until it can be removed out the side.

CAUTION

Avoid jarring or striking the shield; it can become magnetized, thus distorting the trace on the MEMOTRON tube screen.

4-7. MEMOTRON TUBE STORAGE SURFACE. Damage to the MEMOTRON tube storage surface may result if excessive voltage is applied between the collector mesh and the storage mesh, or if the protective resistors, R85, R119, or R268, provided in the MEMO-SCOPE oscilloscope are removed.

Precautions should be taken to avoid wrong connections to the front-end caps. See figure 13 for correct connections.

4-8. MEMOTRON Tube Voltage Ratings: The following ratings given are with respect to the flood gun cathode potential:

Viewing Screen	3000 volts (average)
Ion Repeller Mesh	250 volts
Second Anode	200 volts
Deflection Plates	200 volts (average)
Collector Mesh	205 volts (maximum)
Third Anode	150 volts
Storage Mesh	Adjusted at Factory
First Anode	-1800 volts (average)
Cathode, Writing Gun	-2600 volts (average)
Writing Gun Cathode Heater	6.3 volts at -2600 volts
Flood Gun Cathode Heater	6.3 volts at ground

4-9. ADJUSTMENTS.

4-10. Most adjustment procedures depend upon which preamplifier is being used with the MEMO-SCOPE oscilloscope. For that reason, these adjustments will be found in Section V of this manual, in the paragraphs covering the related preamplifier. Certain minor adjustments will be found in Section III, under the description of the applicable circuit.

4-11. TROUBLE SHOOTING.

4-12. The troubles and their probable causes and suggested remedies discussed following will be found of valuable assistance should any operating difficulties be experienced with the MEMO-SCOPE oscilloscope.

The troubles listed represent the most common type troubles which might be encountered in actual use of

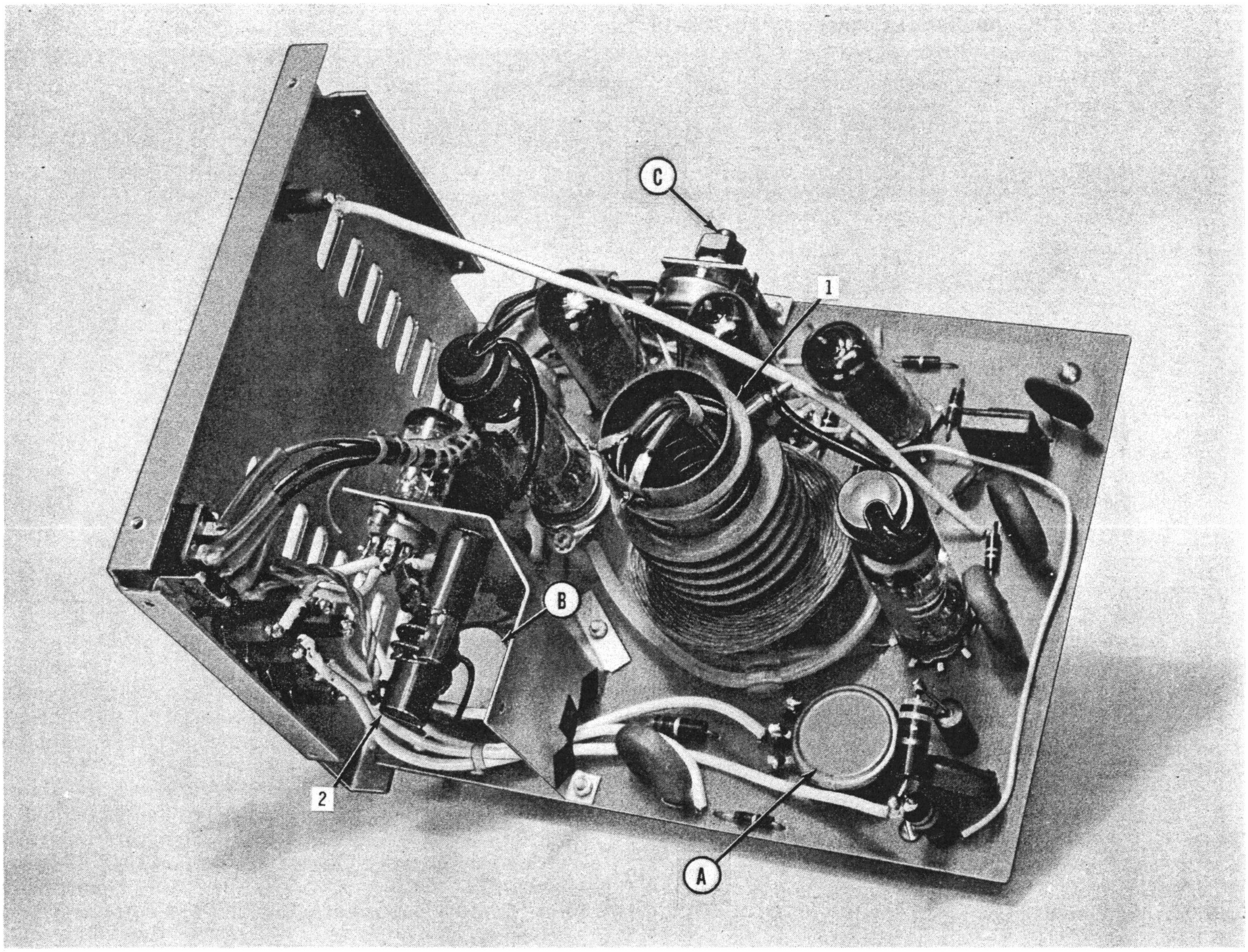


Figure 11. High Voltage Power Supply

KEY TO FIGURE 11:

1. High Voltage Coil, HAC No. E-000116

2. High Voltage Blanking Coil Assembly, HAC No. E-000201

ADJUSTMENT POINTS:

A. Focus Adjustment, R263

B. Intensity Adjustment, R265

C. High Voltage Adjustment, R258

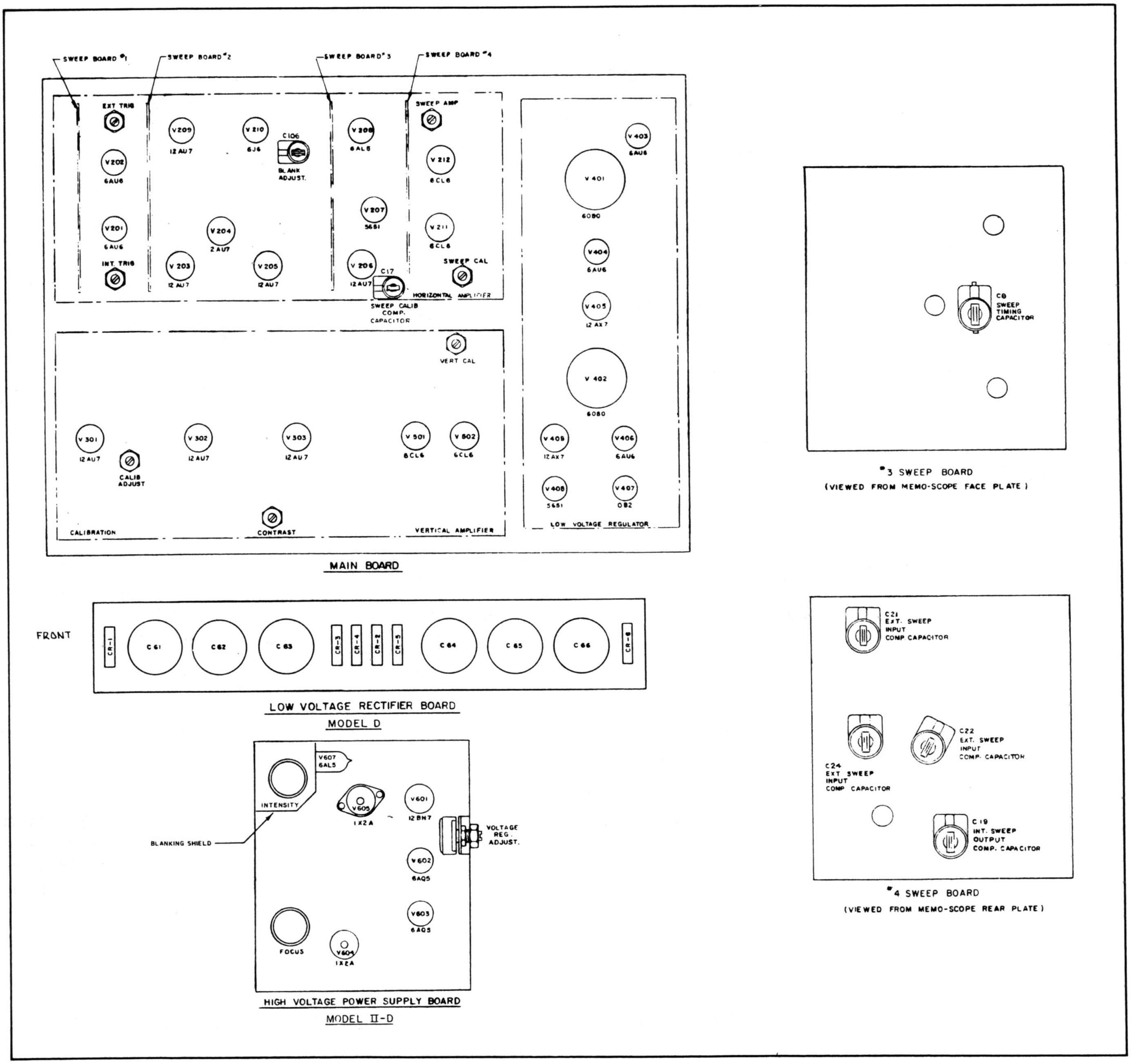


Figure 12. Tube, Potentiometer, and Trimmer Layout, Model 104D

the MEMO-SCOPE oscilloscope, and, in most cases, the repair consists of simple replacements and/or adjustments which can be easily accomplished by the operator. More difficult and extensive repairs may require the services of an experienced technician in a well-equipped instrument depot.

TROUBLE: Sweep changes in width, and is unstable.

This trouble will usually be the result of a failure in the low-voltage power supply section; the -200, +200, and +450-volt sections have changed. Check each voltage (see figure 8), and proceed as follows:

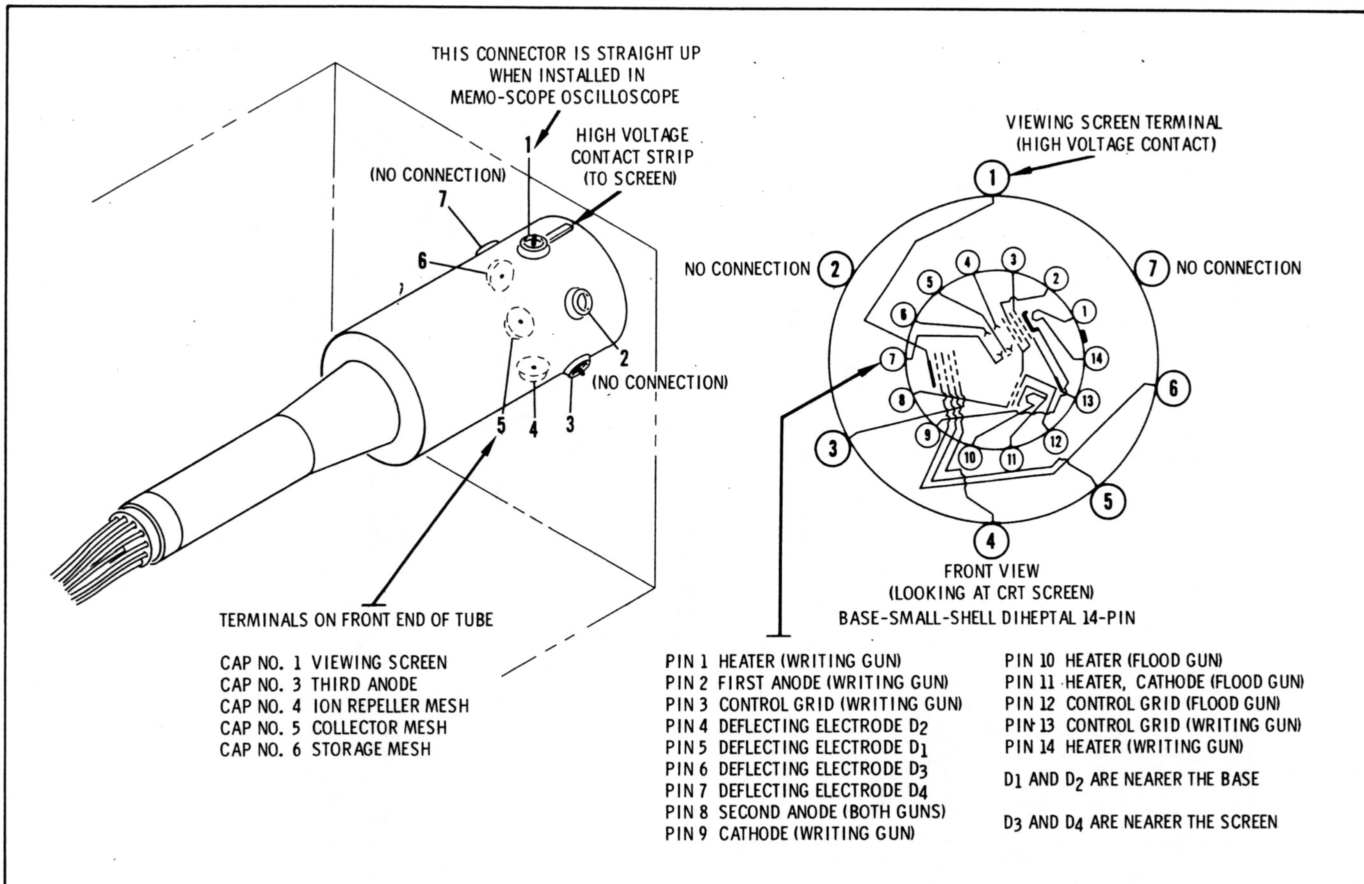


Figure 13. MEMOTRON Tube Pin Locations, and Position of Pins when Installed in MEMO-SCOPE Oscilloscope Chassis

If in +450-volt section, check tubes V401 and V403, and diodes CR1 and CR2.

If in +200-volt section, check tubes V401, V402, V404, and V405, and diodes CR3 and CR4.

If in -200-volt section, check tubes V402, V406, V407, V408, and V409, and diodes CR5 and CR6.

TROUBLE: Continually blows fuses.

Usually a defective diode in the low-voltage power supply; check diodes CR1, CR2, CR3, CR4, CR5 and CR6 (see figure 9).

TROUBLE: Sweep Width changes with INT control:

Probably poor regulation in high voltage power supply.

Check tube V601; check for -2.6 kilovolts at J4. If V601 is replaced, or if -2.6 kilovolt level is incorrect, adjust R258 (see "C", figure 11 and "A", figure 10), use a 20,000 ohms per volt voltmeter for measurement.

If high voltage is not present, check V601, V602, V603, V604, and V605; if any tube is replaced, perform preceding adjustment.

TROUBLE: MEMOTRON tube will not store:

Make sure anode caps are properly and securely installed as shown in figure 13. Check each connection is tight, and not simply disconnected.

Check tubes V302 and V303.

Check R286 (NOTE: This resistor is located inside J5 of the high voltage power supply).

TROUBLE: Sweep circuits intermittent or inoperative.

Visually check to make sure that rotary switch contacts in sweep circuits are correctly lined up with the stationary wipers, in all switch positions. If not, realign rotary switch wafers.

TROUBLE: Jittering of sweep.

Check tubes V203 and V204.

TROUBLE: Defective sweep trigger.

Check tubes V201 and V202.

TROUBLE: Insufficient sweep width.

Check resistor R227; if replaced, readjust R258 in high voltage power supply (see "C", figure 11) for -2. 6 kilovolts at J4.

NOTE:

Do not adjust resistor R39 unless a time mark generator is available for recalibration.

TROUBLE: Defective blanking.

With blanking on, adjust C106 so as to blank out retrace line on CRT screen.

Check tubes V209 and V210.

Check tube V607 (or diodes CR9 and CR10 which are used on older models) in high-voltage power supply.

TROUBLE: Incorrect vertical amplifier sensitivity deflection.

The gain of the main vertical amplifier is factory adjusted so that a 9-volt peak-to-peak input signal will cause a deflection of 10 divisions on the MEMOTRON tube screen. The push-pull input signal can be measured between (or each side with respect to ground) pins 2 or 9 of V501 and pins 2 or 9 of V502. This measurement must be made with the preamplifier installed in the MEMOSCOPE. If necessary adjust the sensitivity with R-115 (see "G" figure 9). The gain should be checked whenever V501 or V502 is replaced.

After adjusting the sensitivity of the main vertical amplifier, check the preamplifier as outlined in Section V.

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SECTION V
MEMO-SCOPE OSCILLOSCOPE ACCESSORIES

5-1. CAMERA MOUNT.

5-2. An optional equipment camera mount (HAC No. E-000146) can be added to the Model 104-D MEMO-SCOPE oscilloscope as shown in figure 1. This mount provides means for mounting any standard oscilloscope camera on the front panel of the MEMO-SCOPE oscilloscope, directly over the MEMOTRON tube screen.

The mount is hinged to the left, and when unlocked with the lever on its right side permits swinging the camera completely out of the way during non-photographic operation, or while setting up the display on the MEMOTRON tube screen.

It is not necessary to remove the camera mount from the MEMO-SCOPE oscilloscope during normal operation; no part of the mount obstructs viewing of the MEMOTRON tube screen.

5-3. SPEED ENHANCEMENT CIRCUIT.

5-4. The Speed Enhancement circuit (see figure 14) is available with the MEMO-SCOPE oscilloscope to obtain an increase in the writing speed of the MEMOTRON tube. The Speed Enhancement circuit is shown installed on the MEMO-SCOPE oscilloscope in figure 9 (index No. 3).

NOTE

> The Speed Enhancement circuit is only available at the time of original purchase of the MEMO-SCOPE oscilloscope.

The normal writing speed of the MEMOTRON tube can be increased by a factor of four or more, depending upon the settings of the two potentiometers (see "L" and "K", figure 9).

Under normal operation of the MEMOTRON tube, the flood gun filament voltage is supplied by the main power transformer, T4, of the MEMO-SCOPE oscilloscope. With the added Speed Enhancement circuit (see figure 14), this filament is supplied by an auxiliary 6.3 volt, 600 ma transformer mounted on the Speed Enhancement printed circuit board. This transformer receives the pulse on the 6.3 volt side which, when the Speed Enhancement circuit is energized, supplies the Speed Enhancement pulse to the flood gun cathode circuit.

The polarity of the pulse is negative, and the amplitude may be varied by the left potentiometer (see "L", figure 9). The amplitude varies with each MEMOTRON tube as to maximum writing speed. The factory setting is for maximum writing speed.

The pulse width, as adjusted by the right potentiometer (see "K", figure 9), is also factory adjusted for a maximum writing speed, with the sweep set at 10 microseconds per division. The range of adjustment of the pulse is approximately zero to 150 volts negative, and should only be readjusted with tube aging or after tube replacement. The pulse width should not be adjusted unless higher writing speeds are necessary.

The Speed Enhancement circuit should be left off during operation of the MEMO-SCOPE oscilloscope in the non-storage mode, or when operating in a storage mode with relatively slow traces.

The ON-OFF switch for speed enhancement is located on the front panel of the MEMO-SCOPE oscilloscope, when installed, on the right side center of the front panel, below the GND connector as shown in figure 1.

NOTE

> It is important that an accurate focus adjustment be made before attempting to write with the Speed Enhancement circuit.

5-5. PREAMPLIFIER WB/4.

5-6. WB/4 DESCRIPTION. The WB/4 is a medium gain preamplifier (shown installed in the MEMO-SCOPE oscilloscope in figure 1) suitable for input levels as low as 10 millivolts and having a frequency response of from dc to 250 kc, down 3 db at 250 kc. The WB/4 is direct-coupled, and carefully balanced to provide low drift. The chassis is shock-mounted to make it insensitive to shock.

5-7. WB/4 CIRCUIT. Input of the WB/4 preamplifier is through the attenuator network at the top of the

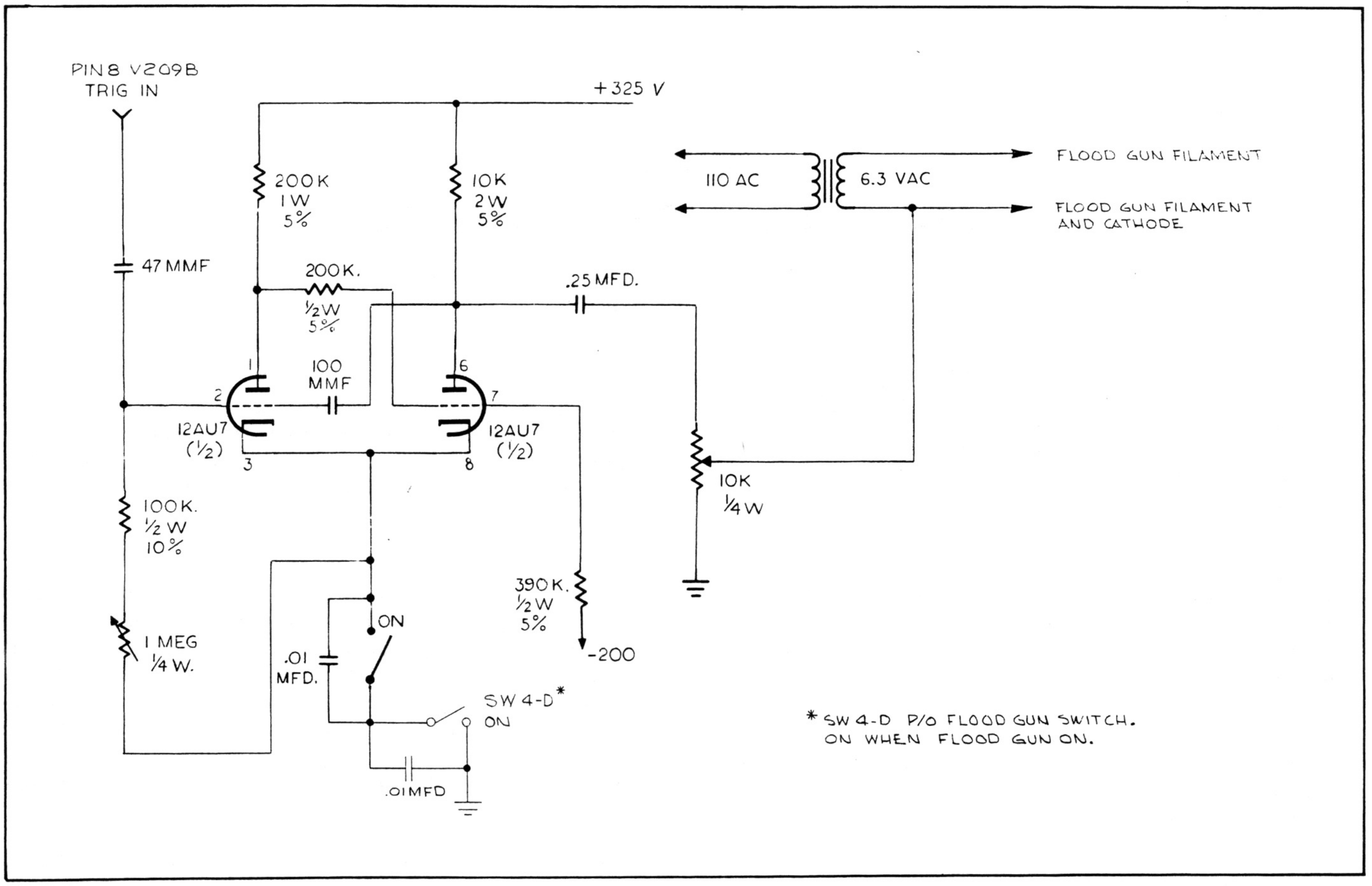


Figure 14. Schematic, Speed Enhancement Circuit

preamplifier, and provides calibrated sensitivities from 0.01 to 50 volts per division on the MEMOTRON screen. The 10:1 gain control provides continuously variable sensitivity between the calibrated steps.

The first stage of the preamplifier (V101 and V102, figure 15) is a pair of 6AU6 tubes connected as a paraphase inverter. The push-pull output is directly coupled to the second stage which consists of the pentode sections of two 6AN8 tubes (V103 and V104), driving the triode sections of these same tubes as cathode followers.

5-8. WB/4 SPECIFICATIONS.

Frequency Response . . . . DC to 250 kc, down 3 db at 250 kc (when used with MEMO-SCOPE oscilloscope main vertical amplifier).

Input . . . . 1 megohm, shunted by 50 mmf. Two inputs, A and B, are provided. AC or DC inputs are provided through mode switch.

Sensitivity . . . . 0.01 to 50 volts per division, in 9 calibrated steps, or continuously variable from 10 millivolts to 50 volts.

5-9. WB/4 OPERATION.

5-10. DC Balance: The BAL control (screwdriver control on the front panel) should occasionally be adjusted to compensate for dissimilarity in the aging characteristics of the amplifier tubes. When properly adjusted, there should be no change in the vertical position of the trace on the MEMOTRON tube screen when the 10:1 GAIN control is rotated.

5-11. DC Balance Procedure

a. Set TIME/DIV to 1 millisecond, TRIG SEL to LINE +, and adjust the TRIG LEVEL controls to obtain a trace on the MEMOTRON tube screen. No signal should be applied to the input.

b. Turn 10:1 GAIN control full counter-clockwise and adjust the MEMO-SCOPE V POS control to place

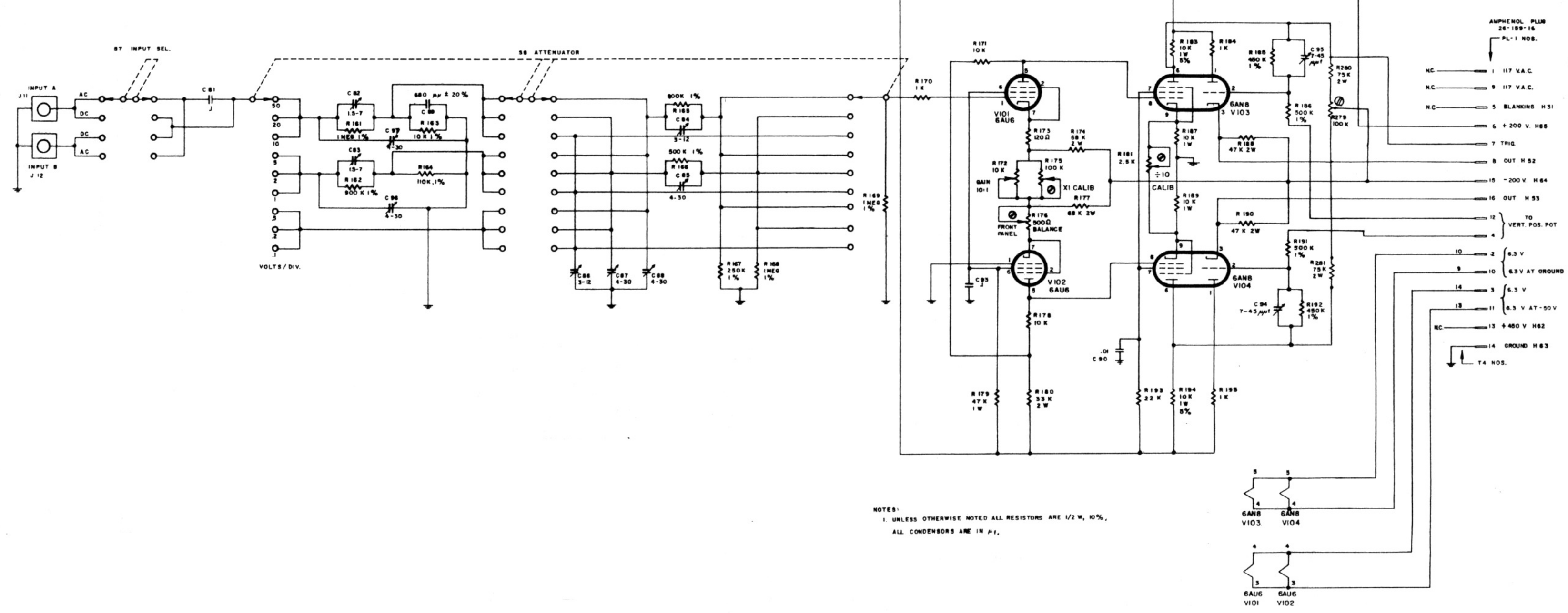


Figure 15. Schematic, WB/4 Preamplifier

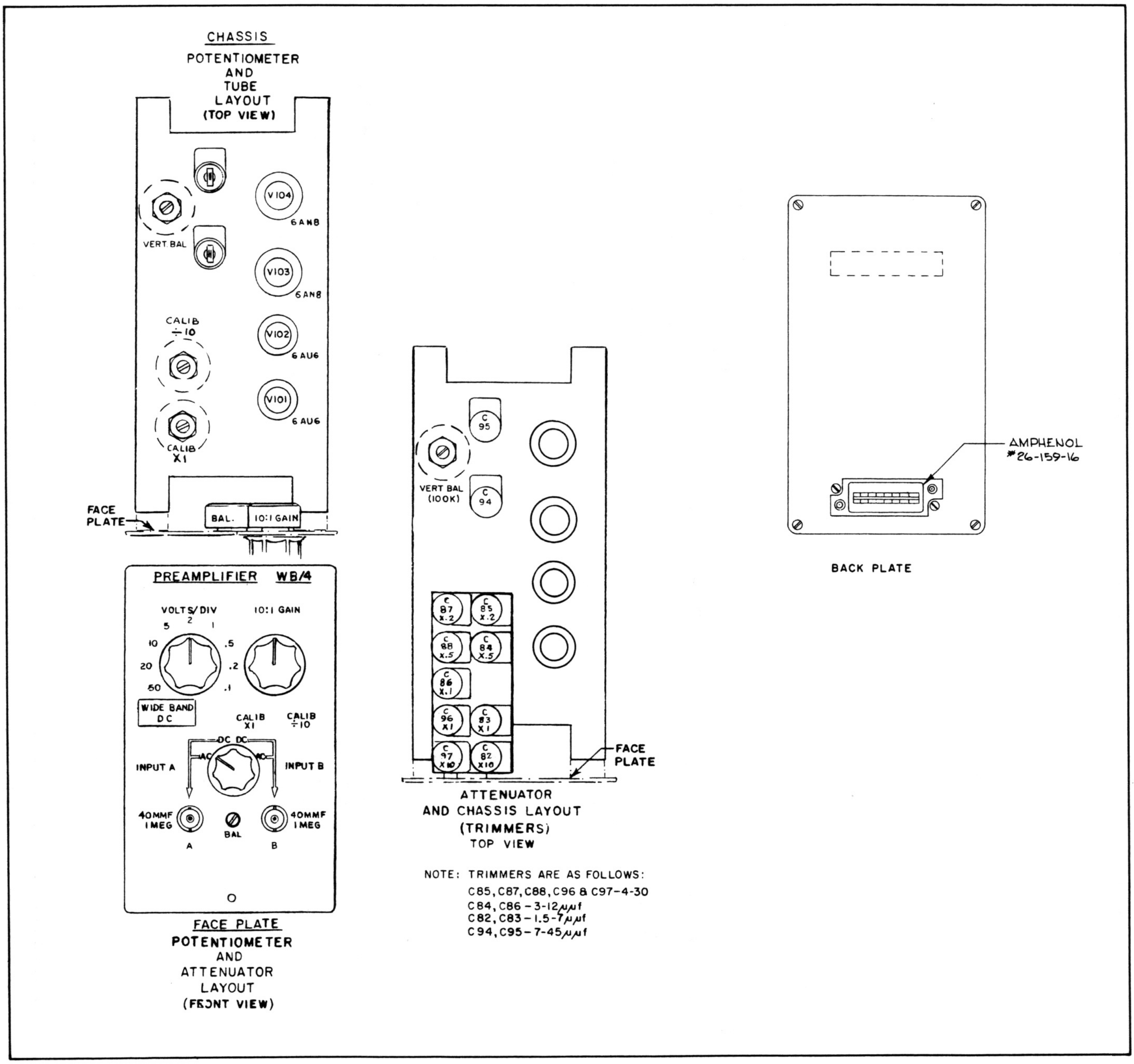


Figure 16. Tube, Potentiometer, and Trimmer Layout, WB/4 Preamplifier

the trace at the center of the reticle.

c. Turn the 10:1 GAIN control full clockwise. The trace will usually move from the center of the screen.

d. Return trace to center of the screen by adjusting the BAL control (screwdriver control on the front panel of the WB/4.)

e. Repeat the above until rotation of the 10:1 GAIN control does not affect the position of trace.

NOTE

If the trace cannot be returned to the center of the reticle in the above procedure see VERTICAL CENTERING ADJUSTMENT paragraph 5-16.

5-12. WB/4 MAINTENANCE. The WB/4 normally requires little maintenance other than normal tube replacement. Should adjustment be necessary, the procedures are outlined in the following paragraphs.

5-13. Typical operating voltages are as follows:

	V101	V102	V103	V104
Plate Voltage	+ 50	+ 50	+125	+125
Suppressor Grid....	+ 2	+ 2	+ 50	+ 50
Screen Grid	+100	+100	+150	+150
Control Grid	0	0	+ 50	+ 50
Cathode	+ 2	+ 2	+ 50	+ 50

NOTE

It will be necessary, for some maintenance work, to use a preamplifier plug-in-extension (accessory part No. E-000119) to permit the WB/4 to operate while it is outside the MEMO-SCOPE case.

5-14. WB/4 ADJUSTMENTS.

5-15. Gain: To calibrate the gain, connect the CAL OUT connector on the MEMO-SCOPE oscilloscope to INPUT A-AC, set CALIB VOLTS switch to 1, and set the WB/4 VOLTS/DIV switch to 1. Turn the 10:1 GAIN control full clockwise, adjust MEMO-SCOPE sweep controls to obtain a display of at least 5 cycles of the square wave on the MEMOTRON tube screen, adjust R181 (see "B", figure 17) until 10 divisions on the MEMOTRON tube screen are obtained. Turn the 10:1 GAIN control full counter-clockwise, set the CALIB VOLTS switch to 10, and adjust R175 (see "C", figure 17) until 10 divisions are again obtained on the screen.

5-16. Vertical Centering: Set TRIG LEVEL controls, both black and red, to "0", TRIG SEL to LINE +, TIME/DIV to 1 millisecond, H POS to approximately ten o'clock, and V POS to mechanical center (white line straight up). Adjust R279 (see "A", figure 17) until the trace on the MEMOTRON tube screen is in the center of the reticle.

5-17. Input Attenuator: The WB/4 preamplifier is factory-adjusted for a frequency response of dc to 250 kc, down 3 db at 250 kc. The attenuator should not require adjustment unless a major repair has been performed. If adjustment is necessary, a pad, calibrated for 1 megohm and 50 mmf, and a square wave generator, with a rise time of better than 0.2 microsecond and a frequency of 5 kc will be required.

WB/4 PREAMPLIFIER ADJUSTMENT TABLE

Step	Connect Input of Preamplifier to:	Position of Attenuator (VOLTS/DIV)	Adjust This Trimmer Capacitor for Square Wave:
1.	Direct to Generator	0.1	C94, C95
2.	Pad to Generator	0.1	C86
3.	Direct to Generator	0.2	C85
4.	Pad to Generator	2.0	C87
5.	Direct to Generator	0.5	C84
6.	Pad to Generator	0.5	C88
7.	Direct to Generator	1.0	C83
8.	Pad to Generator	1.0	C96
9.	Direct to Generator	10.0	C82
10.	Pad to Generator	10.0	C97

Locations of the trimmers referred to in these adjustments are shown on figure 17, and on the layout drawing, Figure 16.

After these adjustments have been made, the square wave should remain constant for all positions of the attenuator. A final check should now be made with a signal generator, adjusting trimmers C94 and C95 for a 3 db loss at 250 kc.

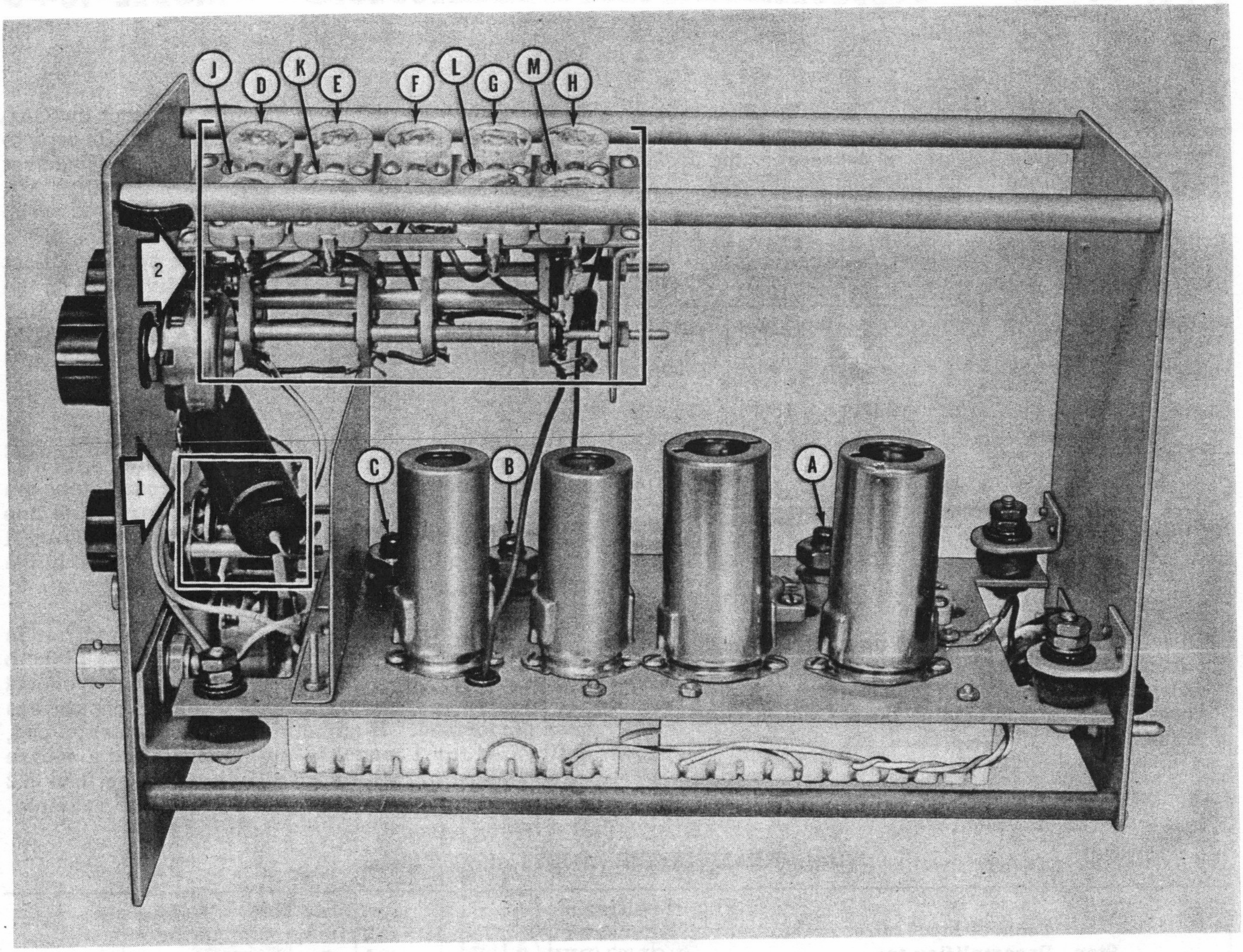


Figure 17. Side View, WB/4 Preamplifier

KEY TO FIGURE 17
1. Input Selector Switch Assembly, HAC No. E-002003
2. Input Attenuator Assembly, HAC No. E-002005

ADJUSTMENT POINTS
A. Centering Potentiometer R279
B. ÷10 Potentiometer R181
C. X1 Calibration Potentiometer R175

Trimmers:

D. C97	G. C88	K. C83
E. C96	H. C87	L. C84
F. C86	J. C82	M. C85

5-18. WB/D1/11 OR WB/D1/11-D DUAL TRACE PRE-AMPLIFIER. (See figure 18.)

5-19. DESCRIPTION. The WB/D1/11 or WB/D1/11-D Dual Trace Preamplifier is specially designed for those applications requiring a simultaneous presentation of two related electrical phenomenon. The Dual Trace Preamplifier contains two similar amplifier channels that may be electronically switched by the MEMO-SCOPE oscilloscope sweep, or by a free running multi-vibrator at approximately 100 kc.

The Dual Trace Preamplifier can be used in the "chopped" mode, the alternate mode, or either of the two amplifiers within the Dual Trace Preamplifier can be used separately.

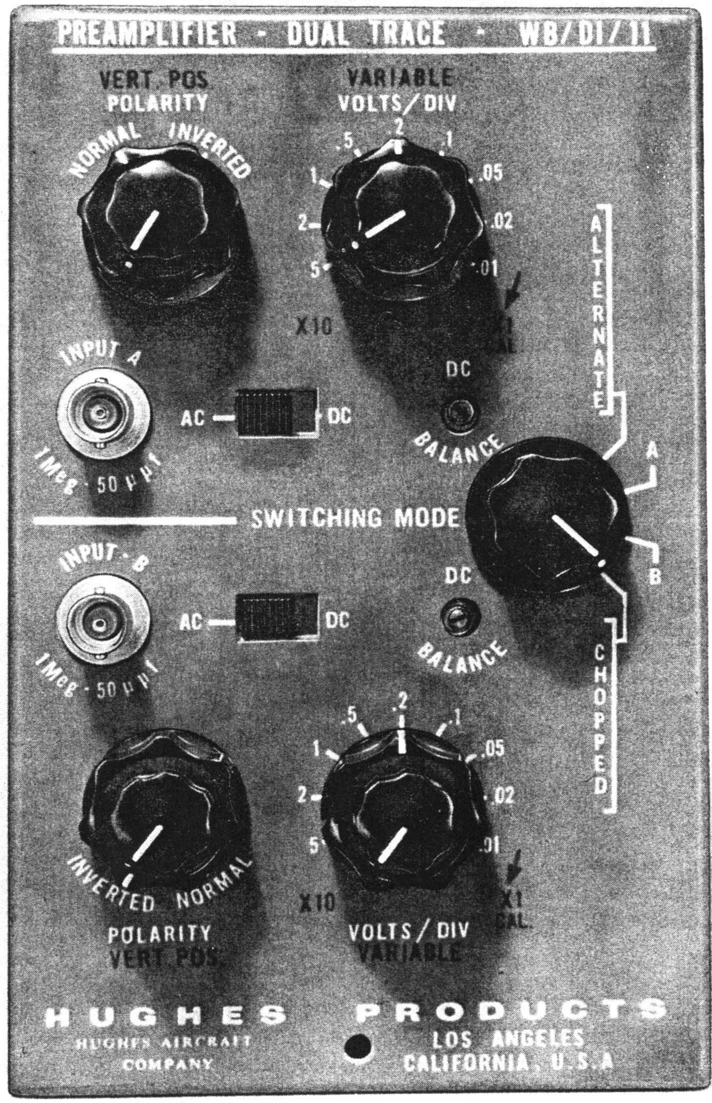


Figure 18. Front Panel, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

5-20. Chopped Mode: In the chopped mode, the two similar amplifiers are electronically switched at approximately the 100 kc rate. This is useful in comparing two signals having frequencies of approximately 10 kc each as to phase relationship and amplitude of the signals. Either repetitive or transient phenomenon can be observed, and the information can be displayed with the MEMOTRON tube in the storage or non-storage mode. It is usually advantageous to display repetitive phenomenon in the non-storage mode, and transient phenomenon in the storage mode.

5-21. Alternate Mode: In the alternate mode, the operation is switched from input A to input B so as to alternately display the two signals. The time differences between the two signals is equal to the sweep, plus the flyback time. For this reason, the alternate mode is not satisfactory for comparing exact phase relationships between two channels.

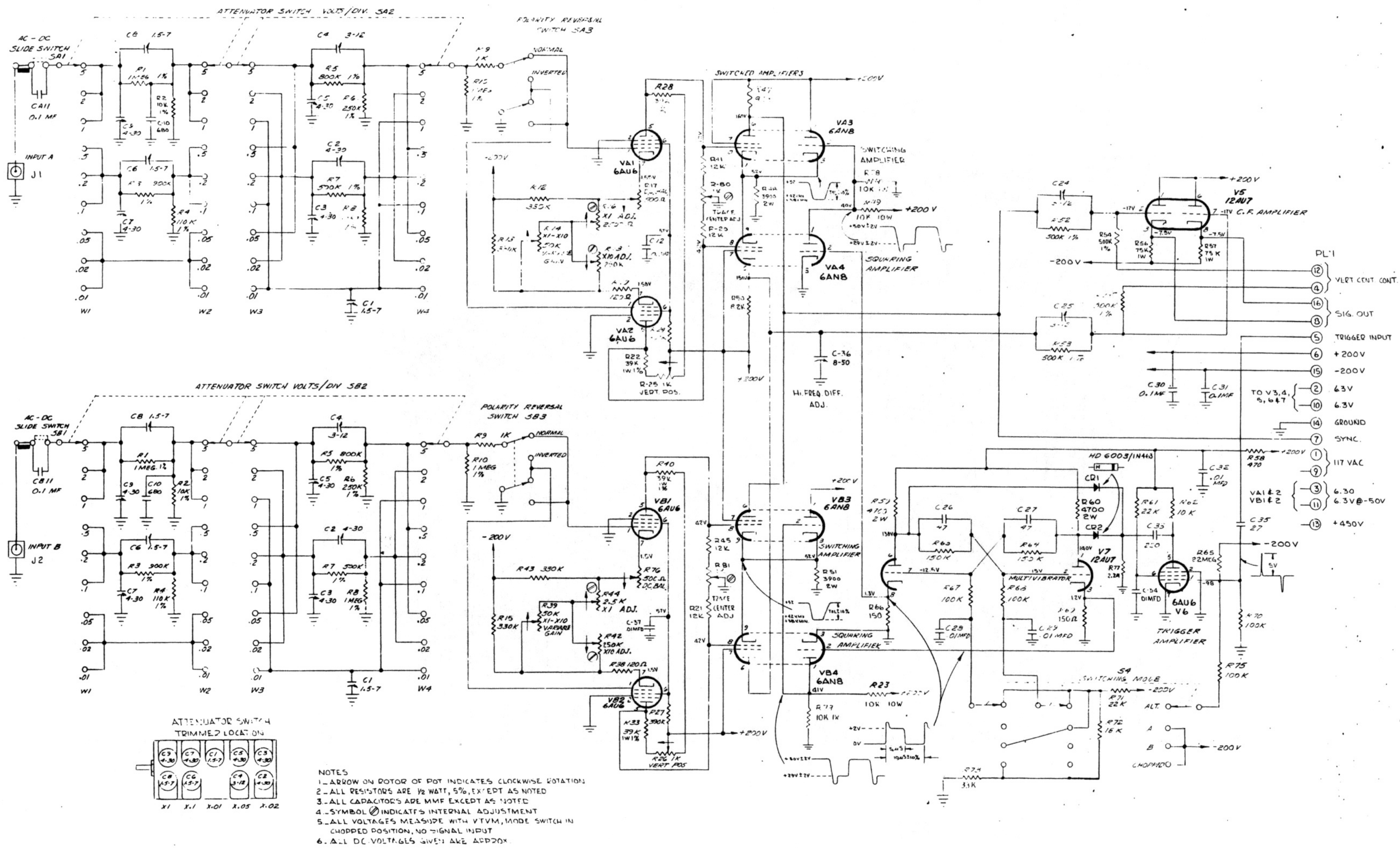


Figure 19. Schematic, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

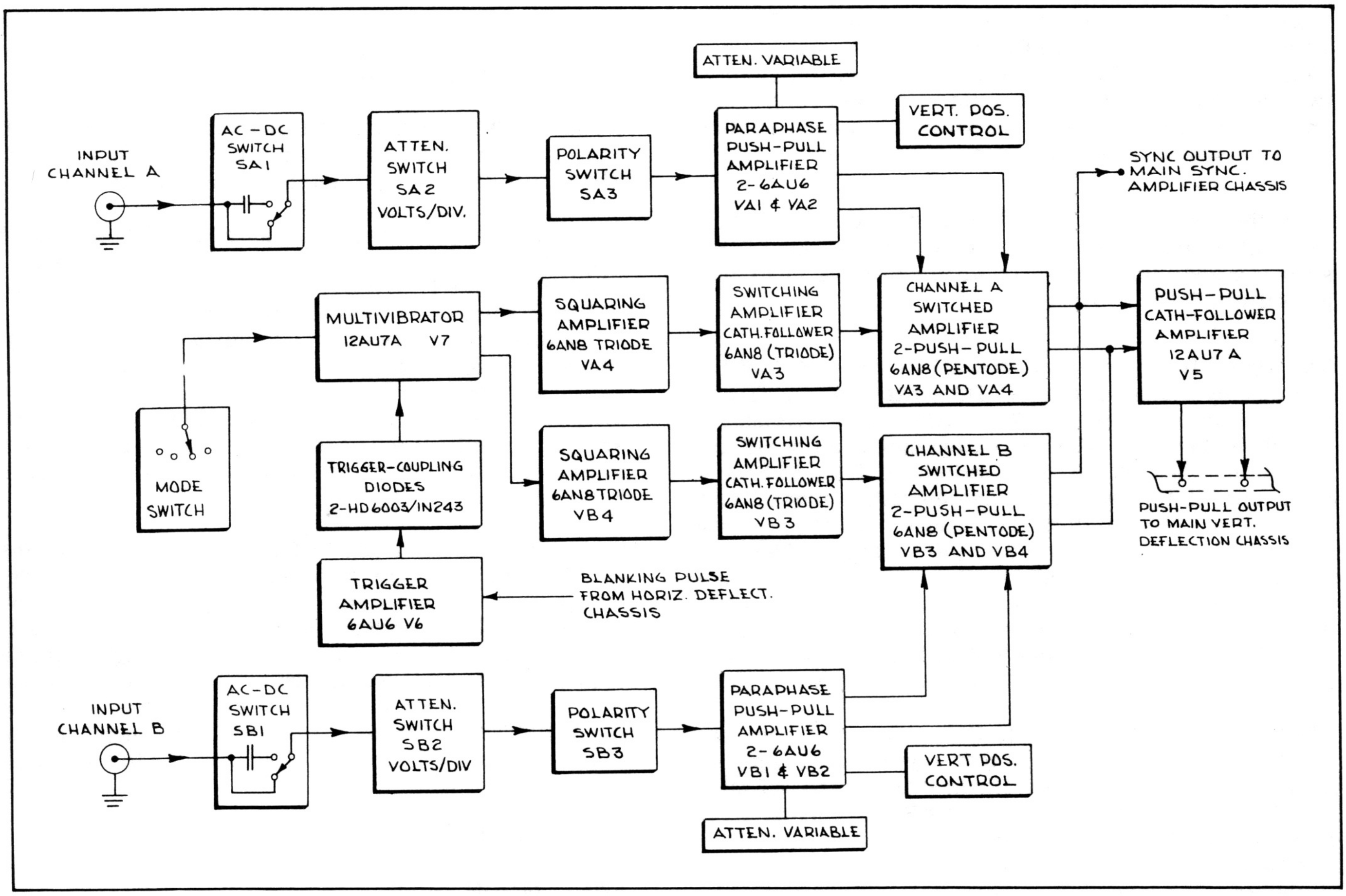


Figure 20. Block Diagram, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

5-22. Independent Amplifiers: Either amplifier channel can be used separately in the Dual Trace Preamplifier, without the electronic switch, making it useful in all signal trace applications within its range of frequency response and sensitivity. Each amplifier has separate controls for positioning, sensitivity, and polarity switching.

5-23. FUNCTIONS OF CONTROLS AND CONNECTORS.

Input A and Input B . . . . Signal input to either Channel A or B amplifiers.

AC-DC . . . . Slide switch to provide either AC or DC coupled input to either amplifier.

VOLTS/DIV. . . . . Nine-position switch used to select the calibrated vertical deflection sensitivity.

VARIABLE . . . . . . Potentiometer control providing continuous variable attenuation between calibrated sensitivity and extending the range to 50 volts per division.

POLARITY . . . . . . Two-position switch for selecting polarity of input signals.

VERT POS . . . . Potentiometer for shifting the vertical position of each amplifier trace independently.

DC BALANCE . . . . Screwdriver adjustment for adjusting DC balance of each amplifier.

SWITCHING MODE . . . . Four-position switch to select either amplifier to be used independently, to be switched at 100 kc rate (chopped mode), or to display traces sequentially (alternate mode).

5-24. WB/DI/11 OR WB/DI/11-D DUAL TRACE PREAMPLIFIER CIRCUIT DESCRIPTION. (See figures 19 and 20.) The Dual Trace Preamplifier consists of two identical amplifier channels, a trigger amplifier, and a multivibrator. The following discussion applies to either channel in single channel operation.

With the SWITCHING MODE switch on the A channel, the multivibrator V7 is cut off by the fixed grid bias, so that a switching action takes place in the switching amplifier, VA3 or VB3.

The signal from the input jack, J1 or J2, is AC or DC coupled by means of the AC-DC switch SA1 or SB1 to the attenuator switch, SA2 or SB2. The attenuator switch makes the AC attenuation equal to the DC attenuation. The POLARITY switch, SA3 or SB3, selects one of the two paraphase amplifier tubes, VA1 and VA2 or VB1 and VB2, to be used, and the polarity of the signal to be observed on the MEMO-SCOPE oscilloscope. VA1 and VA2 (and its B channel twin) are a paraphase amplifier having a common cathode, connected through the variable gain controls, R14, R16, and R18 (or R39, R42, and R44 in B channel), and the DC BALANCE control, R17 (or R76 on B channel).

The DC BALANCE control, R17, equalizes the DC level at the two cathodes so that any DC level appearing at the cathode will not shift the trace on the MEMOTRON tube screen when the VARIABLE control, R14, is changed. When R14 is in the maximum clockwise position, it has shorted out the X10 gain adjust potentiometer, R18 (see "C", figure 24). Therefore, resistance in the cathode circuit is at a minimum, and maximum signal will be observed on the MEMOTRON tube screen.

As R14 is turned counterclockwise, the resistance is increased between the two cathodes, and the signal observed on the CRT screen will decrease. The VERT POS control, R25 (on preamplifier front panel), changes the DC plate voltage, thus giving individual centering for channel A (R26 controls centering of B channel trace).

The signal output of the paraphase amplifier is DC coupled to the switched amplifiers, VA3 and VA4 (VB3 and VB4 for B channel). Trace zero adjustment potentiometer, R80 (channel A; see "F", figure 24) or R81 (channel B; see "E", figure 24) in the grid circuit of these amplifiers enables locating the vertical position controls in the center of their mechanical range, and electrically positioning trace in center of the MEMOTRON tube screen. The signal is then DC coupled to a cathode follower. The cathode follower V5 drives the main vertical amplifiers in the MEMO-SCOPE oscilloscope.

The DC grid bias of the cathode follower is controlled by the VERT POS control on the front panel of the MEMO-SCOPE oscilloscope.

When the SWITCHING MODE switch is in the CHOPPED position, the fixed bias on the multivibrator is reduced. The multivibrator is then free-running at 100 kc.

The multivibrator output is taken off each cathode at low impedance, and fed to the grids of the squaring amplifiers (VA4 or VB4, depending upon channel), which amplify the signal and feed the switched amplifiers through the switching amplifier (VA3 or VB3). The switching amplifier is a cathode follower with sufficient power gain into the low impedance of the switched amplifier to turn it ON and OFF. Thus, the switched amplifiers are turned on and off by a square wave signal applied at the cathode by a 100 kc rate, in 5 microsecond digits.

When operating in the ALTERNATE position, the switching action is the same as in the CHOPPED mode, except that the multivibrator repetition rate is controlled by the repetition rate of the trigger output. The ALTERNATE position removes the high negative bias from the trigger amplifier (V5 or V6), allowing it to conduct when it receives the trigger pulse from the MEMO-SCOPE oscilloscope. The output of the trigger amplifier tube is diode coupled to the multivibrator.

5-25. DUAL TRACE PROCEDURE.

5-26. <u>MODE Switch</u>:

a. Connect a 1 kc square wave to channel A, channel B, and EXT TRIG connectors.

b. Adjust channel A for 3 to 4 division display in the upper half of the MEMOTRON tube screen.

c. Adjust channel B for a similar display in the lower half of the screen.

d. Turn MODE switch to ALTERNATE. Both traces should appear on the screen, with no apparent change in either position of height of either channel A or channel B display.

e. Turn the SWITCHING MODE switch to CHOPPED. The signal should have a chopped appearance. The chopping signal should be checked for a flat top by increasing the sweep rate to 10 microseconds, and setting the TRIG SEL to INT; with the VERTICAL position controls of channel A and channel B adjusted for a chopped signal display of 4 divisions, overshoots on either the leading or trailing edges should be less than one half division of amplitude.

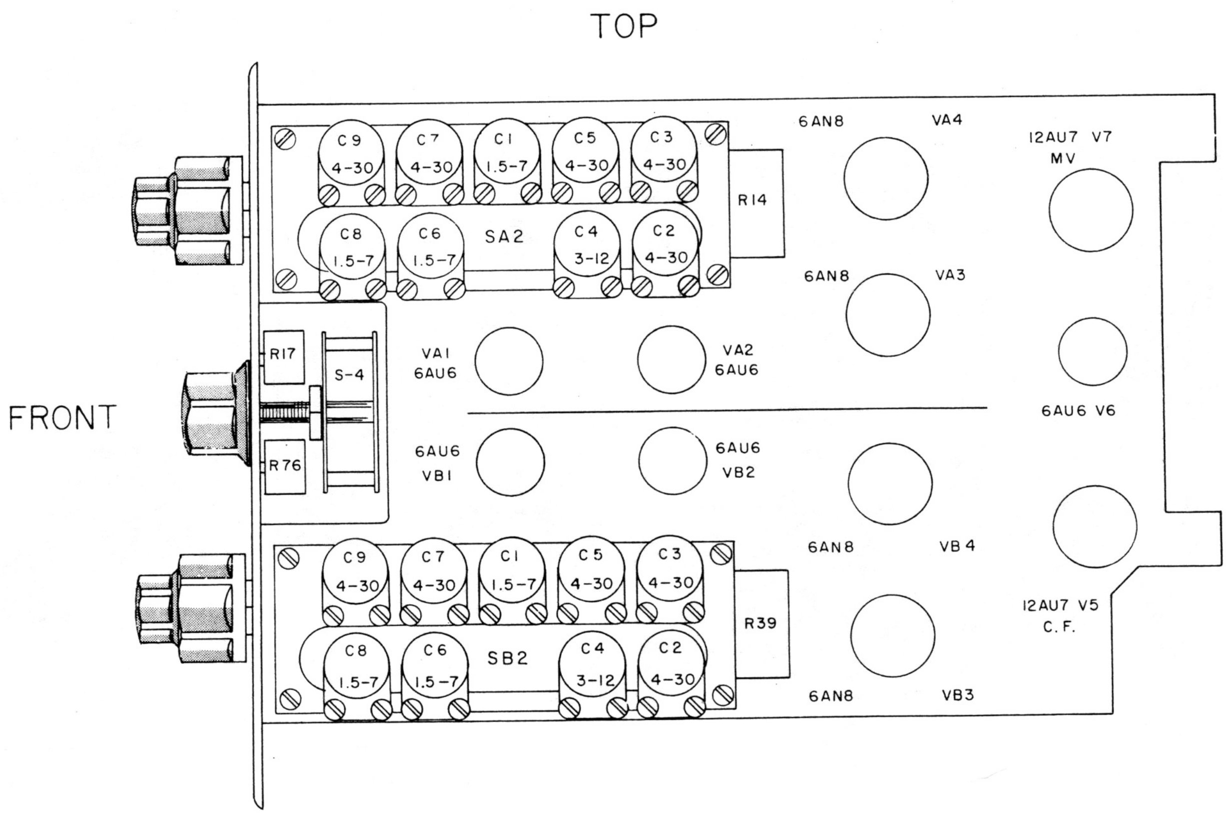


Figure 21. Controls and Tube Layout, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

The chopping action of the electronic switch on the signal may be observed in better detail by increasing the frequency of the input signal to 10 or 50 kc. It will then be observed that each signal is displayed in five microsecond bits.

5-27. DC Balance: The DC BALANCE control (screwdriver control on the front panel) is occasionally touched up to compensate for dissimilarity in the aging characteristics of the amplifier tubes. When properly adjusted, there should be no change in the vertical position of the trace on the MEMOTRON tube screen when the VARIABLE gain control is rotated.

With no signal input, TRIG SEL on LINE, adjust TRIG LEVEL to obtain a line trace. Rotate VARIABLE gain control to X10 position.

Adjust vertical position control (VERT POS) so that the trace is positioned on any convenient horizontal line on the reticle over the face of the MEMOTRON tube. This position should be noted as a reference. Rotate the VARIABLE control clockwise to the X1 position. If the trace moves, adjust the DC BALANCE control until the trace comes back to the previously reference position. Repeat adjustment until rotation of the VARIABLE control does not affect the position of the trace on the MEMOTRON tube screen.

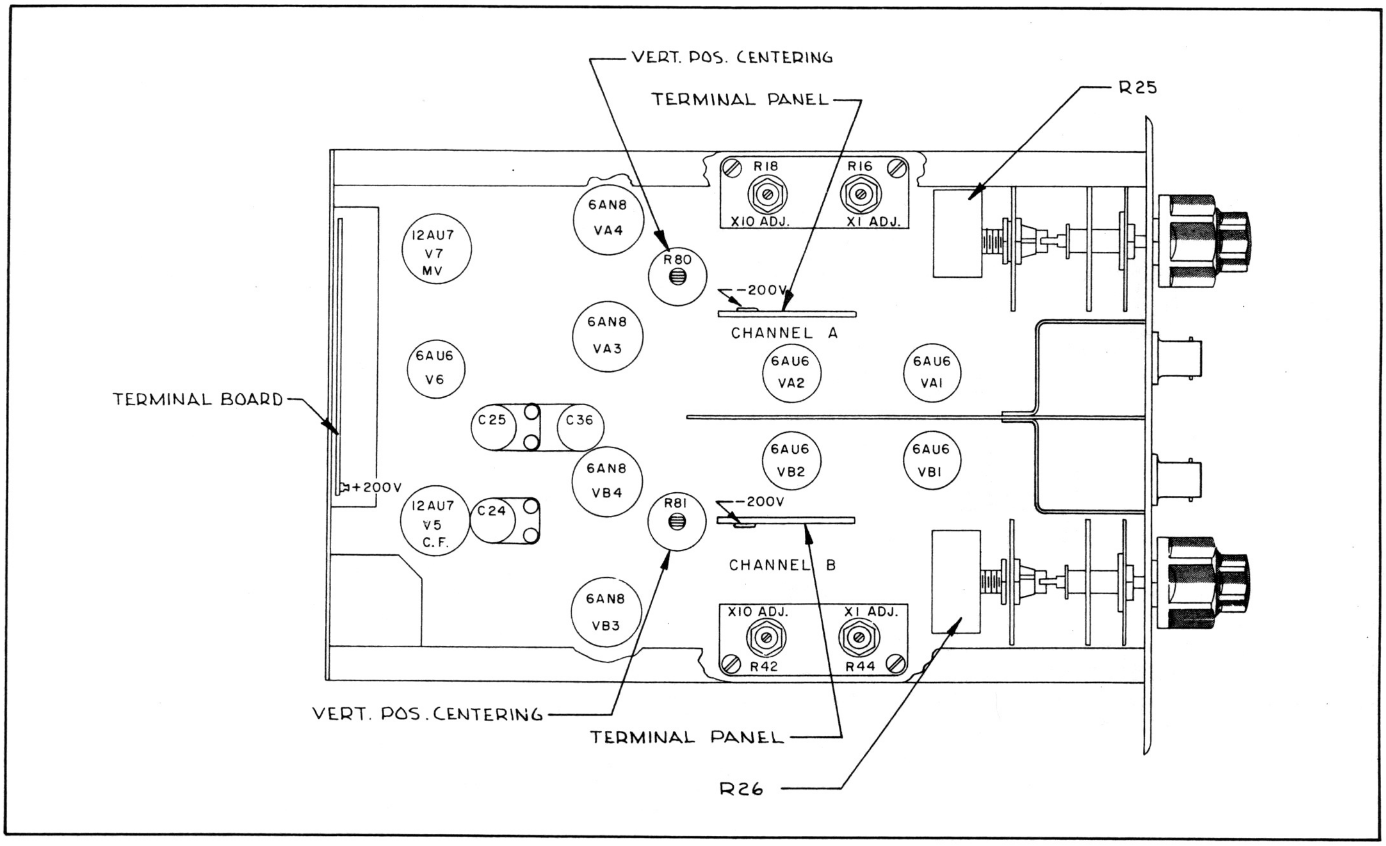


Figure 22. Internal Adjustment Controls and Tube Layout, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

5-28. Vertical Positioning Range: The vertical positioning control (VERT POS) on the MEMO-SCOPE oscilloscope adjusts both traces from the dual trace preamplifier simultaneously. The VERTICAL positioning controls for channels A and B on the dual trace preamplifier adjust the position of either trace independently of the position of the other.

Once the VERTICAL positioning control is adjusted, it need not be touched again, except to obtain greater positioning range, a feature which is useful in single channel operation.

5-29. ADJUSTMENTS, WB/DI/11 OR WB/DI/11-D PREAMPLIFIER.

5-30. Vertical Positioning Range: If tubes are replaced, adjust R80 and R81 as follows:

a. Set all panel vertical positioning controls (on preamplifier and MEMO-SCOPE oscilloscope) to their mechanical centers.

b. With no signal input, position TRIG SEL to LINE, and adjust TRIG LEVEL for a line trace.

c. Check DC BAL control, and adjust if necessary.

d. With MODE switch on channel A, adjust R80 (see "F", figure 24) so that the trace appears on the center of the MEMOTRON tube screen.

e. Move MODE switch to channel B, and adjust R81 (see "E", figure 24) so that trace is in center of screen.

f. Clockwise rotation of the vertical position controls should cause the trace to move upward toward the top of the MEMOTRON tube screen.

5-31. Frequency Adjustment

5-32. High Frequency Response:

a. Position MEMO-SCOPE oscilloscope front panel control as follows:

TRIG SEL . . . . EXT AC
TIME/DIV . . . . 10 MICROSECS
SWEEP MULT X2
TRIG LEVEL . . . . . adjust as required

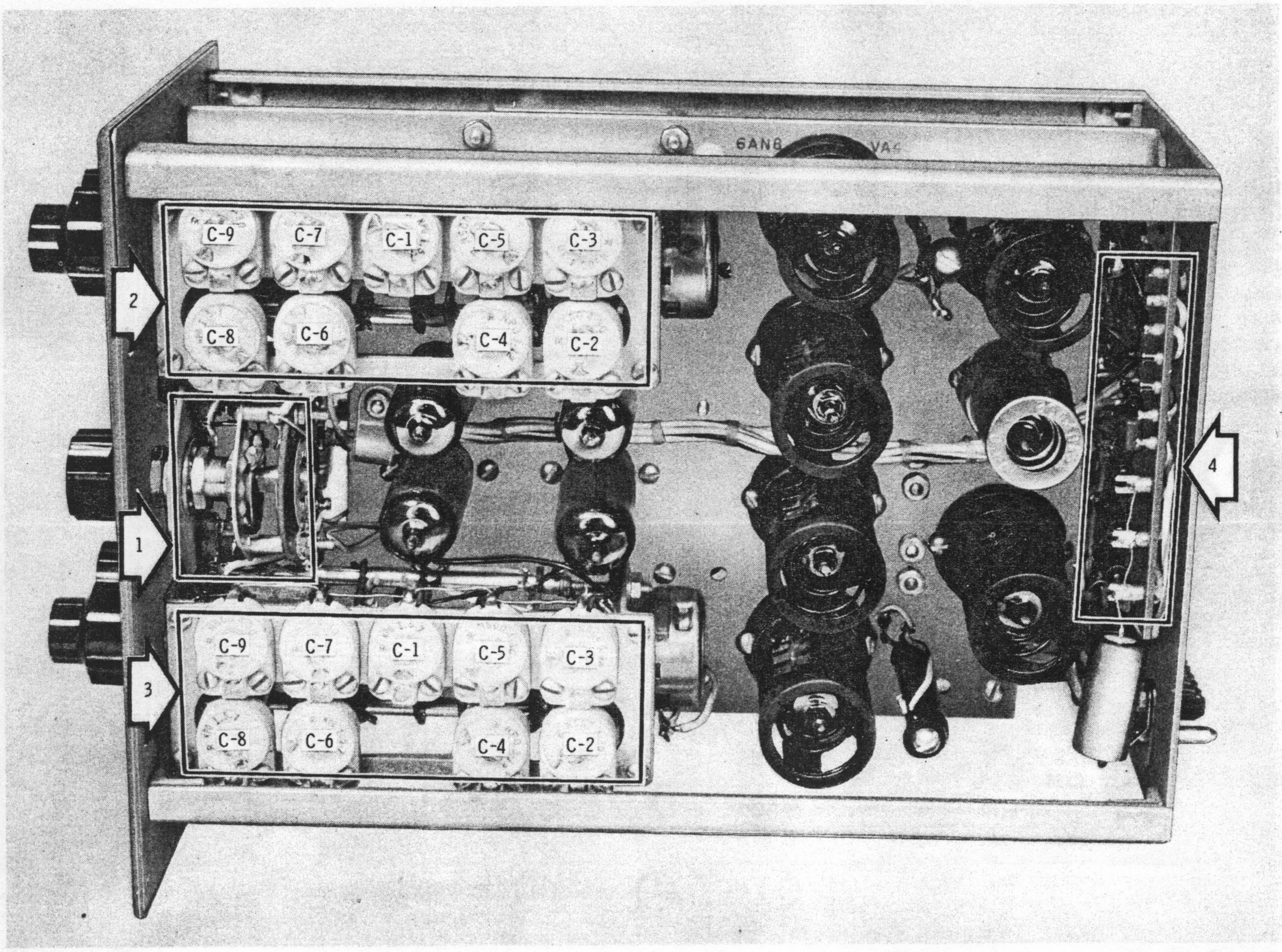


Figure 23. Right-Hand Side View, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

KEY TO FIGURE 23:

1. Mode Switch Assembly, HAC No. E-002813
2. Channel A Attenuator Switch Assembly, HAC No. E-002811
3. Channel B Attenuator Switch Assembly, HAC No. E-002815
4. No. 2 Terminal Board Assembly, HAC No. E-002815

b. Set MODE switch on preamplifier at A or B.

c. Apply a 10 kc signal to channel A and to EXT TRIG connector on MEMO-SCOPE oscilloscope.

d. Ground pin 6 of VA3 through a 1 mfd 200 v capacitor.

e. Observe displayed square wave; adjust C25 (see figure 24) for a flat top on square wave, with minimum overshoot on top and bottom.

f. Ground pin 6 of VA4, and adjust C24 as in step "e" preceding.

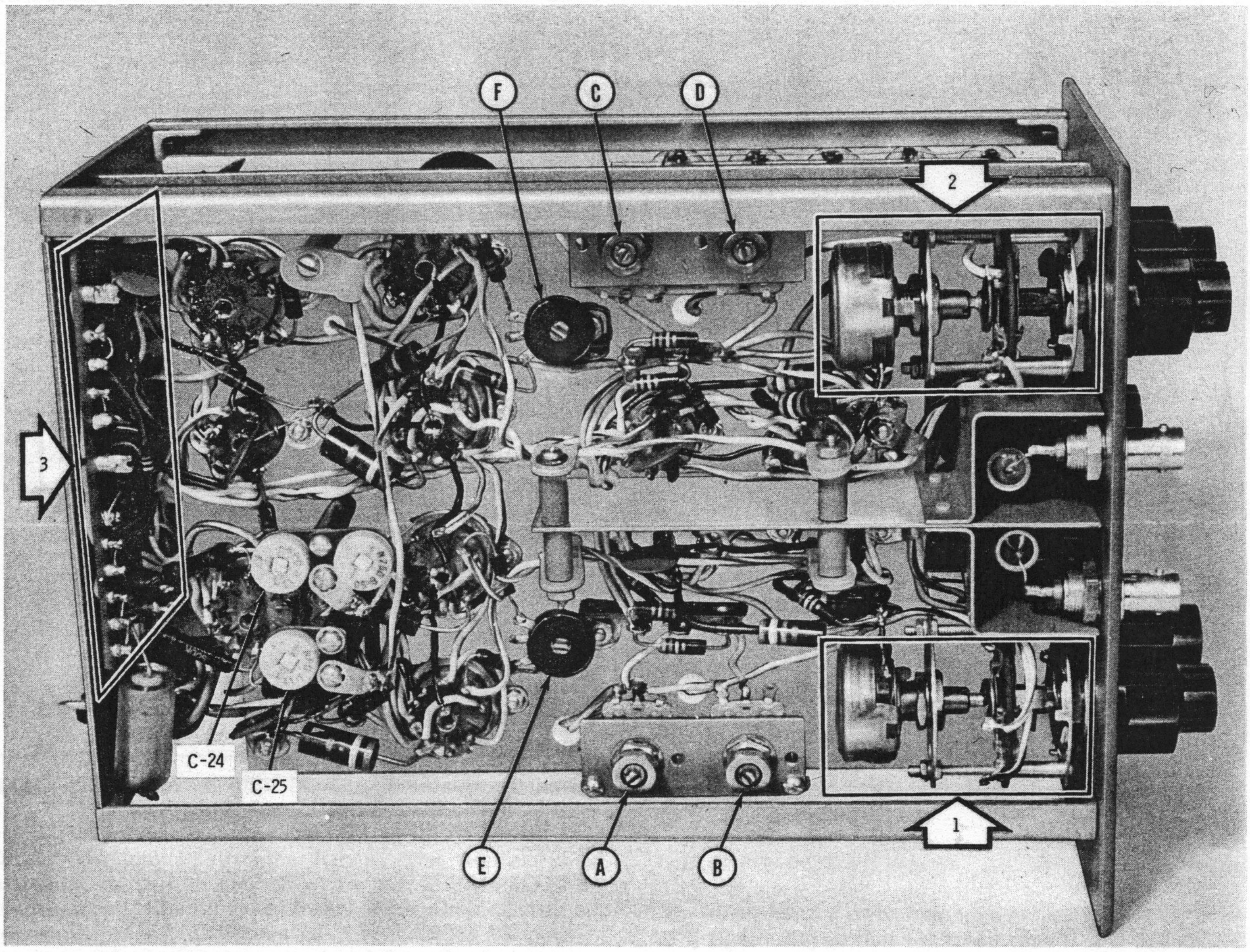


Figure 24. Left-Hand Side View, WB/DI/11 or WB/DI/11-D Dual Trace Preamplifier

KEY TO FIGURE 24:

1. Channel B Polarity and Vertical Centering Assembly, HAC No. E-002824
2. Channel A Polarity and Vertical Centering Assembly, HAC No. E-002824
3. No. 1 Terminal Board Assembly, HAC No. E-002814

ADJUSTMENT POINTS:

A. Channel B, 10:1 Adjustment, R42

B. Channel B Gain Adjustment, R44

C. Channel A 10:1 Adjustment, R18

KEY TO FIGURE 24 (Continued):

D. Channel A Gain Adjustment, R16

E. Channel B Vertical Centering Adjustment, R81

F. Channel A Vertical Centering Adjustment, R80

5-33. Adjustments to Minimize Overshoot:

a. After completion of procedures given in paragraph 5-32, reposition controls as follows:

TRIG SEL	INT AC
SWEEP MULT	X1
TIME/DIV	10 MICROSECS

b. Remove 10 kc input signal, and turn SWITCHING MODE switch on preamplifier to CHOPPED.

c. Adjust A and B VERT POS controls to bring waveform together in center of CRT screen (to obtain a single-line trace).

d. Adjust C36 (see figure 24) to minimize transients and overshoot. The overall remaining signal level (noise) should not be greater than one-half of a division on the graduated reticle.

e. As a final crosscheck, adjust the A and B channel VERT POS controls to obtain a 100 kc display, two divisions above and below the center of the reticle; this display should have a flat top and bottom. Because of trimmer interactions, a slight readjustment of C24 and C25 may be required (refer to paragraph 5-32).

5-34. Overall Gain Adjustment: Set controls as follows:

TRIG SEL	LINE
VOLTS/DIV	0.01
VARIABLE	X1
AC-DC SWITCH	DC
POLARITY	NORMAL

Connect CAL OUT to both channel A and B inputs. Set CALIB VOLTS to 0.1 volt output. Turn SWITCHING MODE switch to channel A. Adjust R16 (see "D", figure 24) for a trace deflection of ten divisions. The output of either pin 8 or pin 3 of the dual trace cathode follower, V5, should be a change of 4.5 volts, or a change of 9 volts between these two pins. If deviation is greater than ±5%, check that the main vertical amplifier in the MEMO-SCOPE oscilloscope has been adjusted properly. (Refer to paragraph 4-11 under TROUBLE: Incorrect Vertical Amplifier Sensitivity Deflection.)

Repeat this check for channel B, except adjust R44 (see "B", figure 24).

5-35. Variable Gain Adjustment: Use same setup as in paragraph 5-33, except:

VARIABLE	X10
CALIB VOLTS	1 volt

On channel A, adjust R18 (see "C", figure 24) for ten divisions deflection; on channel B, adjust R42 (see "A", figure 24) for ten divisions deflection.

5-36. VOLTS/DIV Adjustment: All steps should be adjusted for flat top output, and 50 mmf input capacity. The flat top adjustment should be made at a frequency of 10 kc. Make tests listed in following table with a 10 kc input. Connect the signal generator either directly or through a 1 megohm, 50 mmf pad to input as listed, noting following details:

a. The square wave signal generator is connected directly to the input, and the series capacitor adjusted for a flat top display.

b. A pad, calibrated for 1 megohm and 50 mmf, is then connected between the signal generator and the input to the preamplifier, and the shunt trimmer adjusted for flat top display.

WB/DI/11 OR WB/DI/11-D PREAMPLIFIER ATTENUATOR ADJUSTMENT

STEP ATTENUATOR POSITION:	CONNECT SQUARE WAVE GENERATOR:	ADJUST THESE TRIMMERS FOR FLAT TOP DISPLAY (See figure 23 for trimmer locations):
0.01 V/DIV	Directly to input	C24, C25, and C36 if required
	Through pad to input	C1
0.02 V/DIV	Directly to input	C2
	Through pad to input	C3
0.05 V/DIV	Directly to input	C4
	Through pad to input	C5
0.1 V/DIV	Directly to input	C6
	Through pad to input	C7
1.0 V/DIV	Directly to input	C8
	Through pad to input	C9

SERVICE SUPPLEMENT

MEMO-SCOPE® OSCILLOSCOPE

This service supplement is to be inserted behind the last page of the "MEMO-SCOPE Oscilloscope Model 104-D" instruction manual.

SERVICE SUPPLEMENT

INDUSTRIAL SYSTEMS DIVISION

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

HUGHES AIRCRAFT COMPANY

International Airport Station, Los Angeles 45, California U.S.A.

SERVICE SUPPLEMENT

MEMO-SCOPE® OSCILLOSCOPE

MODEL 104-D

INDUSTRIAL SYSTEMS DIVISION

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

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International Airport Station, Los Angeles 45, California U.S.A.

MI-104D-OA
9/59

TABLE OF CONTENTS

NOTE: This Service Supplement is to be used in conjunction with the MEMO-SCOPE® Oscilloscope instruction manual. Figures referred to in this supplement are those in the manual.

SECTION I

ROUTINE MAINTENANCE AND CALIBRATION

1. LOW VOLTAGE POWER SUPPLY

Measure the –200, +200, +325, and +450 volt output from the low voltage regulator etched circuit board. The –200, +200, and +450 volt sources are regulated and should be within plus or minus 3% of the specified voltage. The nominal 325 volt output is not regulated and should be between 280 and 340 volts. A change in the output voltage of the –200 volt section affects the other two regulated voltages and the +200 volt section affects the +450 volt output. Because of this interaction the –200 volt section output should be checked first, the +200 volt next, and the +450 volt last. If any of these voltages do not meet the specifications, service that section before proceeding to the next.

2. HIGH VOLTAGE POWER SUPPLY

Adjust R258 (see A, figure 10) for a voltage of 4,300 VDC, as measured with a 20,000 ohms per volt meter, at J5 located at the top of the high voltage power supply.

CAUTION

Make certain that the capacitors in the high voltage power supply have been discharged to ground through J5 before servicing this unit.

3. BLANKING OSCILLATOR ADJUSTMENT

3.1 With no input signal set the Memo-Scope® oscilloscope controls as follows:

TRIG SEL to INT AC +
FLOOD GUN to OFF
STORAGE full counter-clockwise
FOCUS full counter-clockwise
TIME/DIV 1 MILLISECOND
INT full counter-clockwise
Black TRIG LEVEL control full clockwise
V POS and H POS approximate mechanical center.

3.2 Note that the SWEEP READY light is lit.

3.3 Turn INT control full clockwise. A spot with an approximate diameter of one-half inch will appear on the MEMOTRON® tube screen.

3.4 Move the spot to the left side of the reticle with the positioning controls and adjust C106 (located at top of MAIN BOARD, figure 12) for minimum brightness of the spot.

CAUTION

KEEP SPOT DEFOCUSED DURING THESE ADJUSTMENTS.

4. ADJUSTMENT OF CALIBRATOR VOLTAGE

4.1 Set the Memo-Scope oscilloscope controls as follows:

TRIG SEL to INT AC+
V POS to mechanical center
H POS to approximately ten o'clock
FLOOD GUN to OFF
STORAGE full counter-clockwise

4.2 Connect an accurate one volt peak-to-peak signal to INPUT A: AC of the preamplifier, adjust the TIME/DIV and TRIG LEVEL controls to obtain at least two complete cycles of the incoming signal, and adjust the gain of the preamplifier so that the height of the signal is exactly 10 divisions on the MEMOTRON tube screen .

4.3 Set the CALIB VOLTS switch to 1, disconnect the standard signal from INPUT A: AC and connect INPUT A: AC to the CAL OUT terminal.

4.4 Adjust the TIME/DIV and TRIG LEVEL controls to obtain at least two complete cycles of the input, and without changing the gain of the preamplifier, adjust R70 (See H, figure 9) until the signal as seen on the MEMOTRON tube screen has an amplitude of 10 divisions.

5. ADJUSTMENT OF TRIGGER LEVEL

5.1 With no signal input set the Memo-Scope oscilloscope controls as follows:

TRIG SEL to LINE +
FLOOD GUN to OFF
STORAGE full counter-clockwise
TIME/DIV 1 MILLISECOND
White dot on black TRIG LEVEL control at "0"
Red TRIG LEVEL full clockwise.

5.2 Adjust INT and FOCUS controls to obtain a fine line on the MEMOTRON tube screen.

5.3 Set TRIG SEL to INT AC + and set R14 (see A, figure 9) at the sweep free-running point. This will not necessarily produce a full-length sweep.

5.4 Set TRIG SEL to INT DC + and set R16 (see B, figure 9) at the sweep free-running point.

5.5 Set TRIG SEL back to INT AC +. If sweep does not trigger as in 5.3 above, readjust R14.

6. SWEEP CALIBRATION

6.1 Set the MEMO-SCOPE® oscilloscope controls as follows:

SWEEP MULT to XI
TRIG SEL to INT AC +
TIME/DIV to 1 MILLISECOND
V POS to mechanical center
H POS to approximately ten o'clock
FLOOD GUN to OFF
STORAGE full counter-clockwise

6.2 Connect a one millisecond marker signal to the input of the preamplifier, set the red TRIG LEVEL control full clockwise, and adjust the black TRIG LEVEL control to obtain a stable trace on the MEMOTRON® tube screen.

6.3 Adjust the preamplifier sensitivity so that the marker pips have an amplitude of between one and two divisions on the reticle.

6.4 Set the white dot on the ASTIG control knob opposite the red dot on the front panel of the oscilloscope and proceed to paragraph 6.5. If the red dot on the front panel is missing, turn the INT control counter-clockwise until the trace is just barely visible and then turn the black TRIG LEVEL control full clockwise.

WARNING

KEEP INTENSITY OF WRITING BEAM AS LOW AS POSSIBLE.

Hold the BLANKING switch down, reduce intensity as much as possible, and with the positioning controls move the spot to the center of the reticle. While still holding the BLANKING switch down, and keeping the intensity as low as possible, yet still visible, adjust the ASTIG and FOCUS controls for the smallest round spot. Place a mark on the front case of the MEMO-SCOPE oscilloscope opposite the white indicator on the ASTIG control knob. Readjust black TRIG LEVEL control as in 6.2.

NOTE

The MEMO-SCOPE oscilloscope will be calibrated with the ASTIG control in this position. The instrument should be operated at all times with this setting; any change will affect the calibration.

6.5 Adjust the sweep calibration control, R39 (see F, figure 9), so that eleven pips are displayed on the MEMOTRON tube screen.

6.6 Adjust the sweep amplitude control, R227 (see E, figure 9), so that the marker pips fall in line with the vertical lines of the reticle.

6.7 Readjust R39 for a display of twelve marker pips with the length of the trace limited to one-sixteenth inch after the last pip. Include in the count the first pip which may not be seen due to blanking action.

6.8 The calibration for sweep speeds of 100 microseconds, 10 and 100 milliseconds, and 1 second per division can be checked with the appropriate marker generator frequency. Before the sweep speed is set to a lower range make CERTAIN THAT the INTENSITY OF the writing BEAM IS DECREASED TO PREVENT DAMAGE to the MEMOTRON tube. At the 10 and 100 millisecond and 1 second per division sweep speeds make the check with the MEMO-SCOPE oscilloscope in the storage mode and with the writing beam defocused so that it has a diameter almost as great as one-eighth inch. Use only enough intensity to allow storage of the trace on the tube screen. The adjustment of R39 affects the calibration of all of the sweep speeds and is usually adjusted on the 1 millisecond per division range.

6.9 In preparation for the calibration of the 10 microsecond per division sweep range, apply a 10 microsecond marker signal to the input of the preamplifier, set the TIME/DIV to 10 microseconds, and set the remaining controls as in 6.1 through 6.4.

6.10 With the red TRIG LEVEL full clockwise adjust C17, Sweep Calib. Comp. Capacitor (see MAIN BOARD, figure 12) for a display of 8 to 10 marker pips.

6.11 Adjust C8, Sweep Timing Capacitor (see #3 SWEEP BOARD, figure 12) so that the marker pips on the right side of the trace line up with the vertical lines of the reticle. The red TRIG LEVEL control can be used for stability.

6.12 Adjust C19, Int. Sweep Output Comp. Capacitor (see #4 SWEEP BOARD, figure 12) so that the marker pips on the left side of the trace line up with the vertical lines of the reticle.

6.13 Repeat the adjustment of C8 as in 6.11 followed by the adjustment of C19 as in 6.12 until the trace is linear and is in calibration.

6.14 While holding the BLANKING switch down adjust C17, Sweep Calib. Comp. Capacitor (see MAIN BOARD, figure 12) so that 12 pips are displayed with the red TRIG LEVEL control in the full clockwise position.

7. VERTICAL AMPLIFIER SENSITIVITY ADJUSTMENT

7.1 Set the CALIB VOLTS switch to 10 and connect the CAL OUT terminal to the input of the preamplifier. Adjust the sweep controls to obtain at least three complete cycles of the waveform on the MEMOTRON tube screen.

7.2 Adjust the preamplifier gain controls so that the applied signal has a height of exactly 10 divisions on the reticle.

7.3 Measure the push-pull signal between pins 2 or 9 of V501 and pins 2 or 9 of V502 (or each tube with respect to ground). This signal should be 9 volts ±5%. If out of tolerance, set the gain of the preamplifier to obtain the proper amplitude of signal and then adjust R115 (see G, figure 9) to obtain a deflection of 10 divisions on the MEMOTRON tube screen.

SECTION II

TYPICAL VOLTAGE MEASUREMENTS

All of the following voltage measurements are representative of those taken with a vacuum tube voltmeter and with the MEMO-SCOPE® oscilloscope control settings as outlined for each group of measurements.

Group I

Set the MEMO-SCOPE® oscilloscope controls as follows:

TRIG SEL to INT AC +

TIME/DIV to 1 MILLISECOND

FLOOD GUN to OFF

Red TRIG LEVEL control full counter-clockwise

Black TRIG LEVEL control either full counter-clockwise or full clockwise as indicated by the CCW or CW in the column.

TUBE	TRIG LEVEL	PIN NUMBER							
		1	2	3	4	5	6	7	8
V201	CCW	0	.5	—	—	42	92	.5	—
	CW	0	12	—	—	195	81	12	—
V202	CCW	—11	.5	—	—	185	92	.5	—
	CW	12	12.5	—	—	32	81	12	—
V203	CCW	42	0	0	—	—	42	0	0
	CW	195	—48	0	—	—	32	—62	0
V204	CCW	42	—58	0	—	—	42	—58	—16
	CW	165	—64	0	—	—	32	0	0
V205	CCW	104	—16	0	—	—	106	—95	—90
	CW	.5	0	0	—	—	5	—95	—96
V206	CCW	200	104	108	—	—	440	190	200
	CW	100	.5	5	—	—	440	90	108
V207	CCW	190	108	—	—	190	—	—	—
	CW	90	5	—	—	90	—	—	—
V208	CCW	104	—16	—	—	—16	—	104	—
	CW	100	0	—	—	0	—	0	—
V209	CCW	195	—58	—19	—	—	195	1	10
	CW	195	—64	—19	—	—	195	1	10
V210	CCW	180	180	—	—	—50	—50	0	—
	CW	180	180	—	—	—50	—50	0	—

Group II

Set the MEMO-SCOPE® oscilloscope controls as follows:

TRIG SEL to INT AC +

TIME/DIV to 1 MILLISECOND

TRIG LEVEL controls (both black and red) full clockwise

FLOOD GUN to OFF

FOCUS full counter-clockwise.

While holding the BLANKING switch down adjust the H POS and V POS controls so that the large round spot is exactly in the center of the reticle.

TUBE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
V211	5	0	120	—	—	205	5	120	0
V212	4	— .5	120	—	—	215	4	120	— .5
V501	—9	—11	110	—	—	225	—9	110	—11
V502	—9	—12	110	—	—	240	—9	110	—12

Group III

Set the MEMO-SCOPE® oscilloscope controls as follows:

TRIG SEL to INT AC +

TIME/DIV to 1 MILLISECOND

TRIG LEVEL controls (both black and red) full clockwise

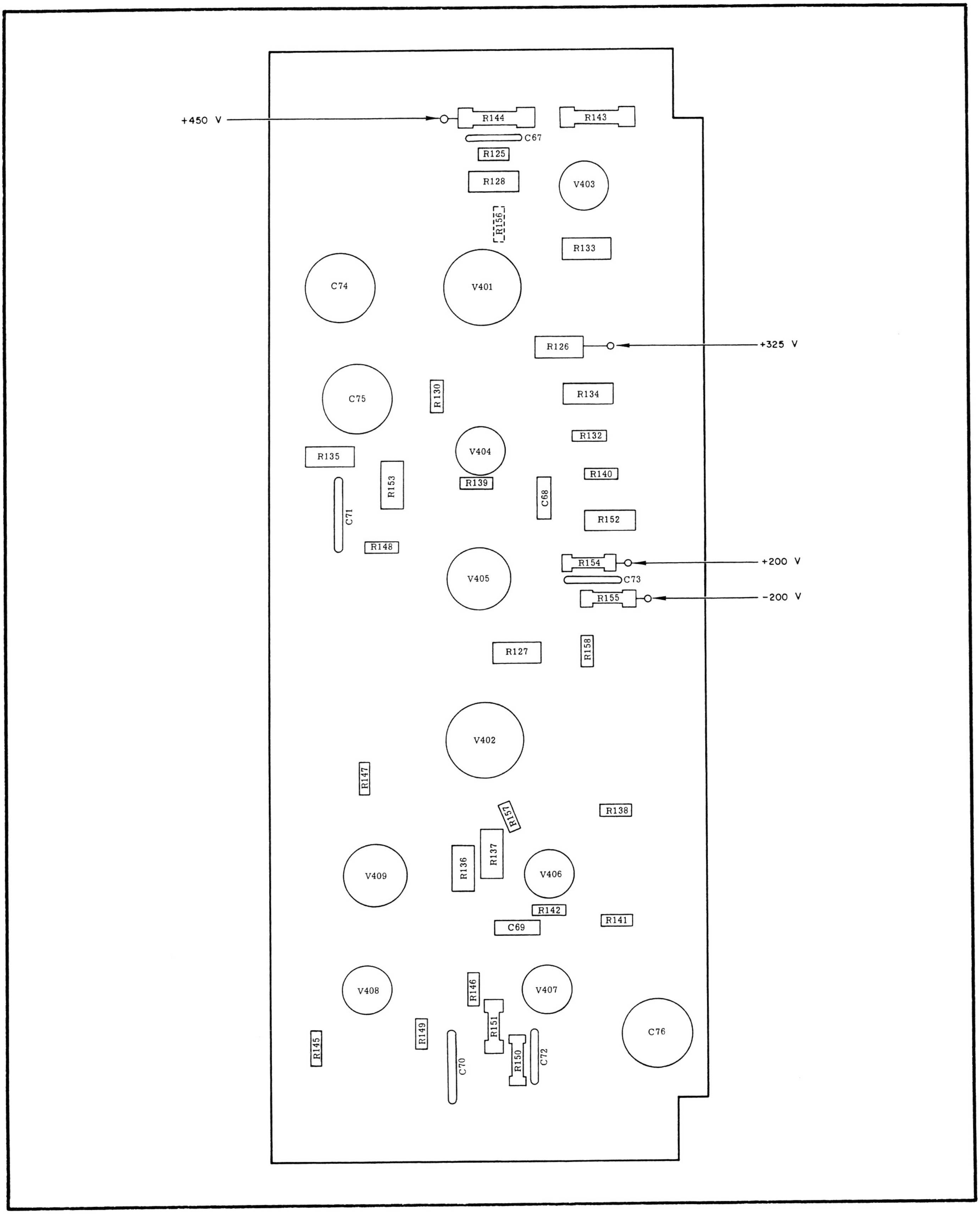
FLOOD GUN ON or OFF as indicated

STORAGE control either full counter-clockwise or full clockwise as indicated by the CCW or CW in the column.

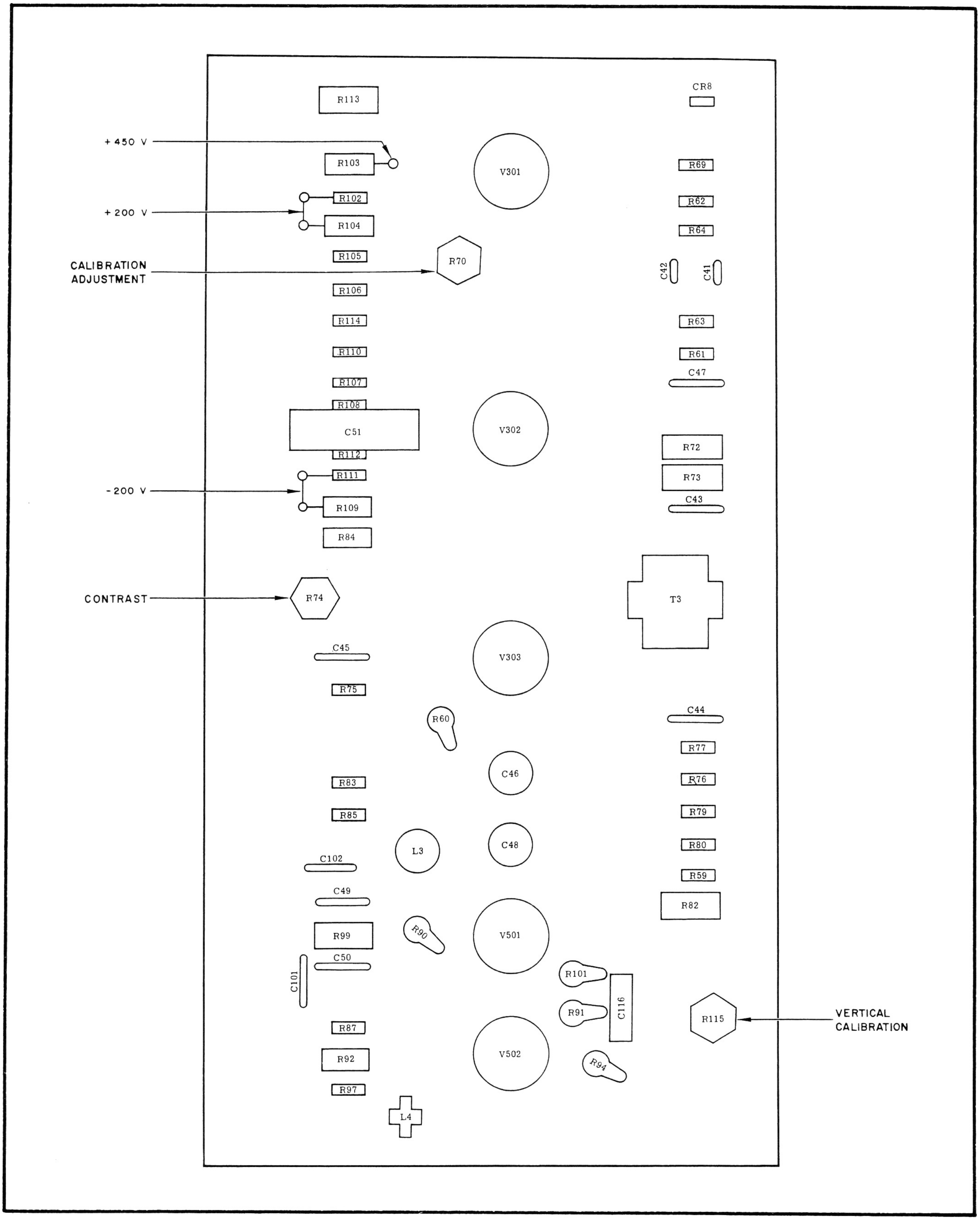
TUBE	FLOOD GUN	STORAGE	PIN NUMBER							
			1	2	3	4	5	6	7	8
V301	OFF	CCW	68	—30	—4.4	—	—	75	—30	0
V302	OFF	CCW	70	—11	0	—	—	70	—11	0
	ON	CCW	52	—12	.3	—	—	52	—12	.3
V303	OFF	CCW	440	—10	50	—	—	50	50	50
	ON	CCW	440	0	50	—	—	50	50	50
	ON	CW	430	200	205	—	—	205	205	205

SECTION III

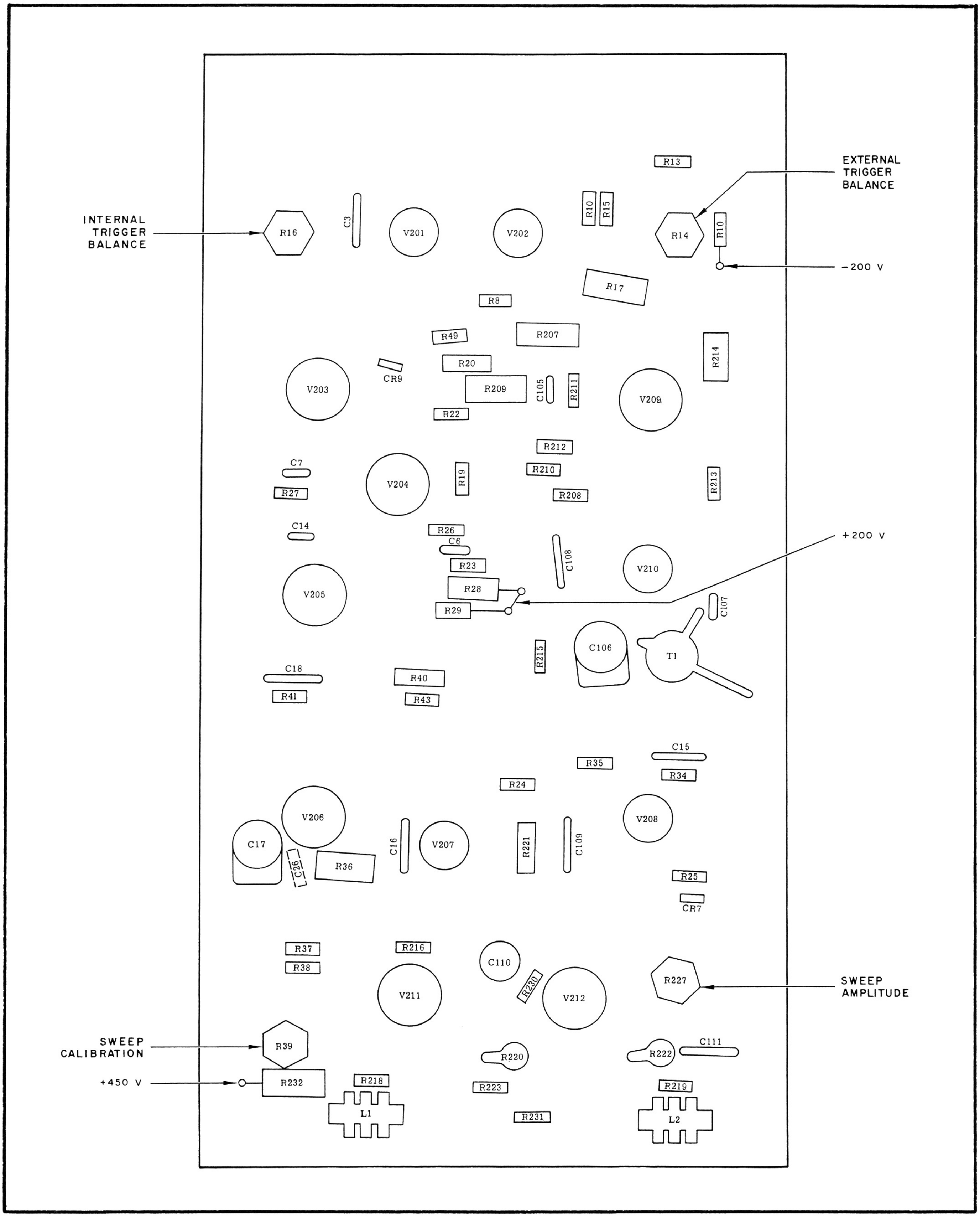
LOCATION OF PARTS



Low Voltage Regulator, Location of Parts



Calibrate Voltage, Storage Circuit, and Vertical Amplifer Location of Parts



Sweep Circuits, Blanking, and Horizontal Amplifier, Location of Parts

SECTION IV

PARTS LIST

MEMO-SCOPE® OSCILLOSCOPE MODEL 104D
AND WB/4 PREAMPLIFIER

RESISTORS

R1	1 MEG
R2	2.2 MEG
R3	150K
R4	1 MEG
R5	
R6	22 MEG
R7	47K 1W
R8	68K
R9	47K 1W
R10	1.8 MEG
R11	1.8 MEG
R12	1 MEG**
R13	100K
R14	100K
R15	100K
R16	2.5 MEG
R17	39K 2W
R18	1 MEG
R19	470K
R20	33K 1W 5%
R21	1.8 MEG
R22	300K 5%
R23	300K 5%
R24	100K
R25	18K
R26	220K 5%
R27	220K 5%
R28	33K 1W 5%
R29	300K 5%
R30	1 MEG
R31	5 MEG 1%
R32	2 MEG 1%
R33	1 MEG 1%
R34	120K
R35	100K
R36	100K 2W
R37	1 MEG
R38	1.5 MEG
R39	1 MEG
R40	22K 1W
R41	1 MEG
R42	1 MEG
R43	1 MEG
R44	82K
R45	1 MEG 1%
R46	900K 1%
R47	100K 1%
R48	10 MEG**
R49	100K
R50	200K**
R51	
R52	1 MEG
R53	5K*
R54	47K 2W 5%
R55	47K 2W 5%
R56	
R57	
R58	4.7 1W
R59	1K
R60	20K 10W WW
R61	47K
R62	1 MEG
R63	1 MEG
R64	47K
R65	5.1K 1%
R66	510 1%
R67	51 1%
R68	5.6 1%
R69	82K
R70	25K***
R71	
R72	27K 2W
R73	33K 2W
R74	250 2W***
R75	100K
R76	47
R77	47
R78	
R79	100K
R80	1 MEG
R81	100K 2W*
R82	150K 2W
R83	120
R84	10K 1W
R85	470
R86	270K 5%
R87	560K 5%
R88	
R89	33K
R90	10K 10W WW
R91	10K 5W
R92	12K 1W
R93	33K
R94	10K 10W WW
R95	
R96	
R97	560K 5%
R98	270K 5%
R99	1.5K 2W
R100	3K 4W Pot. WW
R101	10K 5W
R102	27K
R103	100K 1W
R104	15K 1W
R105	100K
R106	47K
R107	120
R108	120
R109	100K 1W
R110	8.2K
R111	100K
R112	33K
R113	47K 2W
R114	27K
R115	500 2W Pot.***
R116	100K
R117	
R118	
R119	2.2 MEG
R120	
R121	50 10W WW Pot.
R122	4.7 1W
R123	4.7 1W
R124	4.7 1W
R125	100K
R126	47 1W
R127	47 1W
R128	33K 1W
R130	120
R132	100K
R133	33K 1W
R134	33K 1W
R135	33K 1W
R136	3.9K 2W
R137	4.7K 2W
R138	100K
R139	1 MEG
R140	1 MEG
R141	1 MEG
R142	(Note 1)
R143	2.4 MEG 1W 1%
R144	1.5 MEG 1W 1%
R145	47K
R146	10K
R147	470K
R148	10K
R149	56K
R150	1 MEG 1%
R151	800K 1%
R152	150K 1W
R153	390K
R154	1 MEG 1%
R155	1 MEG 1%
R156	120
R157	120
R158	120
R159	
R160	
R161	1 MEG 1%
R162	900K 1%
R163	10K 1%
R164	110K 1%
R165	800K 1%
R166	500K 1%
R167	250K 1%
R168	1 MEG 1%
R169	1 MEG 1%
R170	1K
R171	10K
R172	10K 2W*
R173	120
R174	68K 2W
R175	100K 2W***
R176	500 2W***
R177	68K 2W
R178	10K
R179	47K 1W
R180	33K 2W
R181	2.5K 2W***
R182	
R183	10K 1W 5%
R184	1K
R185	450K 1%
R186	500K 1%

RESISTORS (CONT'D)

R187	10K 1W
R188	47K 2W
R189	10K 1W
R190	47K 2W
R191	500K 1%
R192	450K 1%
R193	22K
R194	10K 1W 5%
R195	1K
R196	
R197	
R198	
R199	
R200	
R201	
R202	
R203	
R204	
R205	1 MEG
R206	3.9 MEG
R207	22K 2W
R208	3.9K
R209	39K 2W
R210	1.5 MEG
R211	1.5 MEG
R212	120
R213	27K
R214	68K 1W
R215	1K
R216	1K
R217	270K 5%
R218	22K
R219	22K
R220	25K 10W 5% WW
R221	20K 1W
R222	25K 10W 5% WW
R223	560K 5%
R224	10K 2W 5%
R225	10K 2W 5%
R226	2K 2W**
R227	1K
R228	10K 2W 5%
R229	10K 2W 5%
R230	1K
R231	560K 5%
R232	2.7K 2W
R233	270K 5%
R234	1 MEG
R235	100K
R236	100K
R237	1 MEG
R238	250K 2W*
R239	
R240	
R241	
R242	
R243	
R244	
R245	1K
R246	47
R247	47K
R248	120
R249	47
R250	1K
R251	120K
R252	47K 2W
R253	47K 2W
R254	120
R255	2.2 MEG
R256	1 MEG
R257	100K
R258	1 MEG 2W***
R259	1 MEG
R260	3.3 MEG 2W
R261	3.3 MEG 2W
R262	3.3 MEG 2W
R263	5 MEG 2W*
R264	1.8 MEG 1W
R265	1 MEG 2W*
R266	100K
R267	100K
R268	2.2 MEG
R269	470K
R270	22K
R271	22K
R272	100K
R273	1 MEG
R274	
R275	
R276	
R277	
R278	
R279	100K 2W***
R280	75K 2W
R281	75K 2W
R282	
R283	
R284	
R285	
R286	
R287	
R288	
R289	
R290	
R291	
R292	
R293	
R294	
R295	
R296	
R297	
R298	
R299	
R300	

Note 1. R142 is from 560K to 1 MEG. Selected at factory for proper output voltage of —200V regulated supply

* AB Pot CU

** Part of Dual Pot

*** AB Pot CLU

CAPACITORS

C1	47 (C)
C2	47 Mica
C3	.01 GMV (C)
C4	.01 GMV (C)
C5	47 GMV (C)
C6	100 GMV (C)
C7	100 GMV (C)
C8	7-45 Erie
C9	.001 3% (P)*
C10	.01 3% (P)*
C11	.1 3% (P)*
C12	1 3% (P)*
C13	10 3% (P)
C14	100 GMV (C)
C15	.01 GMV (C)
C16	.01 GMV (C)
C17	7-45 Erie**
C18	.01 GMV (C)
C19	7-45 Erie
C20	220 GMV (C)
C21	7-45 Erie
C22	7-45 Erie
C23	220 GMC (C)
C24	7-45 Erie
C25	.1 GMV (P)
C26	47 GMV (C)**
C27	
C28	
C29	
C30	
C31	
C32	
C33	
C34	
C35	
C36	
C37	
C38	
C39	
C40	
C41	470 GMV (C)
C42	470 GMV (C)
C43	.1 GMV (P)
C44	.01 20% 600V (C)
C45	.01 GMV (C)
C46	1.0 250V P (PC)
C47	.01 GMV (C)
C48	1.0 250V P (PC)
C49	.01 GMV (C)
C50	.01 GMV (C)
C51	.002 GMV (C)
C52	12 250V (E)
C53	
C54	

CAPACITORS (CONT'D)

C55		C88	4-30 Erie	C121	.0015 GMV (C) 6KV
C56		C89	680 20%	C122	.01 GMV 600V
C57		C90		C123	.01 GMV (C)
C58		C91		C124	.01 GMV (C)
C59		C92		C125	.0015 GMV (C) 6KV
C60		C93	.1 600V (T) (P)	C126	.01 GMV (C)
C61	200 200V (PC) E	C94	7-45 Erie	C127	27 GMV (C)
C62	200 200V (PC) E	C95	7-45 Erie	C128	27 GMV (C)
C63	200 200V (PC) E	C96	4-30 Erie	C129	.0015 GMV (C) 6KV
C64	200 200V (PC) E	C97	.01 (T)	C130	27 20% C-T GMV
C65	200 200V (PC) E	C98		C131	.0015 GMV (C) 6KV
C66	200 200V (PC) E	C99		C132	100 GMV (C)
C67	.01 GMV (C)	C100		C133	
C68	100 GMV (C)	C101	.01 GMV (C)	C134	
C69	100 GMV (C)	C102	.01 GMV (C)	C135	
C70	.02 GMV (C)	C103		C136	
C71	.02 GMV (C)	C104		C137	
C72	.01 GMV (C)	C105	47 (C)	C138	
C73	.01 GMV (C)	C106	7-45 Erie	C139	
C74	10 350V (E) (PC)	C107	47 20% (C)	C140	
C75	10 350V (E) (PC)	C108	.01 GMV (C)		
C76	10 350V (E) (PC)	C109	.01 GMV (C)	*	These timing capacitors
C77		C110	.05 GMV (PC)		are padded at the
C78	47 Mica 200V	C111	.01 GMV (C)		factory during first
C79		C112			sweep calibration
C80		C113		**	C26 is used in some
C81	.01 GMV (P) (T)	C114			units to pad C17
C82	1.5-7 Erie	C115	.001 GMV (C)		
C83	1.5-7 Erie	C116	2000 GMV Mica	(P)	Paper
C84	3-12 Erie	C117	.01 GMV (C)	(T)	Tubular
C85	3-12 Erie	C118	.0015 GMV (C) 6KV	(C)	Ceramic
C86	3-12 Erie	C119	.0015 GMV (C) 6KV	(E)	Electrolytic
C87	4-30 Erie	C120	.0015 GMV (C) 6KV	(PC)	Printed Circuit

TUBES

V101	6AU6	V210	6J6	V407	OB2
V102	6AU6	V211	6CL6	V408	5651
V103	6AN8	V212	6CL6	V409	12AX7
V104	6AN8	V301	12AU7	V501	6CL6
V201	6AU6	V302	12AU7	V502	6CL6
V202	6AU6	V303	12AU7	V601	12BH7
V203	12AU7	V401	6080	V602	6AQ5
V204	12AU7	V402	6080	V603	6AQ5
V205	12AU7	V403	6AU6	V604	1X2B
V206	12AU7	V404	6AU6	V605	1X2B
V207	5651	V405	12AX7	V606	6498
V208	6AL5	V406	6AU6	V607	6AL5
V209	12AU7				

MISCELLANEOUS

CR_1 thru CR_6 — Silicon Rectifier (M-500)
CR_7 thru CR_9 — IN68-A Diode
L_1 and L_2 — 10 milli henrys
L_3 and L_4 — 950 micro henrys
L_5 and L_6 — 1.5 milli henrys
IL_1 thru IL_5 — Omni-Glow #1090 A-1
IL_6 — NE51 Pilot Light
IL_7 and IL_8 — #47 Pilot Light